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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

MULTI ATTRIBUTE DECISION ANALYSIS IN PUBLIC HEALTH – ANALYZING EFFECTIVENESS OF ALTERNATE MODES OF DISPENSING

by

Sinan Khan

September 2007

Thesis Advisor:	A. Richter
Co-Advisor:	Lauren. Wollman

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Local emergency planners are creating mass prophylaxis plans to prophylax entire populations within forty eight hours in order to reduce mortality after a bioterrorist attack. The Points of Dispensing (PODs) used in prophylaxis are central to an area's mass prophylaxis plans, but they are insufficient because of their staffing and security constraints. Several alternate modes of dispensing that have similar attributes and are considered best practices are presently being implemented in local health departments (LHDs). The purpose of this thesis is to develop models to evaluate alternate modes of dispensing using multi-attribute value function (MAVF), an approach that supports multi-attribute decision-making by taking into account the trade-offs a decision-maker is willing to make between attributes. Two models are created for Los Angeles County (LAC). The models showed that in LAC, the door-to-door option, pharmacy option, civil service option and Kaiser Permanente option work best. The study finds that alternate modes of dispensing can be useful in filling the gaps in the POD-based approach by increasing critical resources or lowering the pressure on existing resources.

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MULTI ATTRIBUTE DECISION ANALYSIS IN PUBLIC HEALTH – ANALYZING THE EFFECTIVENESS OF ALTERNATE MODES OF DISPENSING

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Submitted in partial fulfillment of the
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ABSTRACT

Local emergency planners are creating mass prophylaxis plans to prophylax entire populations within forty eight hours in order to reduce mortality after a bioterrorist attack. The Points of Dispensing (PODs) used in prophylaxis are central to an area's mass prophylaxis plans, but they are insufficient because of their staffing and security constraints. Several alternate modes of dispensing that have similar attributes and are considered best practices are presently being implemented in local health departments (LHDs). The purpose of this thesis is to develop models to evaluate alternate modes of dispensing using multi-attribute value function (MAVF), an approach that supports multi-attribute decision-making by taking into account the trade-offs a decision-maker is willing to make between attributes. Two models are created for Los Angeles County (LAC). The models showed that in LAC, the door-to-door option, pharmacy option, civil service option and Kaiser Permanente option work best. The study finds that alternate modes of dispensing can be useful in filling the gaps in the POD-based approach by increasing critical resources or lowering the pressure on existing resources.

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LIST OF ACRONYMS AND ABBREVIATIONS

BERM	-	Bioterrorism and Epidemic Response Model
CDC	-	Centers for Disease Control and Prevention
CERT	-	Community Emergency Response Teams
DHHS	-	Department of Health and Human Services
DHS	-	Department of Homeland Security
DMA	-	Disaster Management Areas
DPH	-	Department of Public Health
EMS	-	Emergency Medical Services
ESAR-VHP	-	Emergency System for Advanced Registration of Volunteer Healthcare Professionals
FEMA	-	Federal Emergency Response Agency
FPC	-	Force Protection Committee
HMO	-	Health Maintenance Organization
HRSA	-	Health Resource and Services Administration
ICS	-	Incident Command System
LAC	-	Los Angeles County
LHD	-	Local Health Department
MAVF	-	Multi-Attribute Value Function
MMRS	-	Metropolitan Medical Response System
MOA	-	Memorandum of Agreement
MOU	-	Memorandum of Understanding
NPS	-	National Pharmaceutical Stockpile
PODs	-	Points of Dispensing
PPE	-	Personal Protective Equipment
SIPs	-	Sheltered in Populations
SNS	-	Strategic National Stockpile
SPA	-	Service Planning Areas
UASI	-	Urban Area Security Initiative
USMS	-	United States Marshall Service
USPS	-	United States Postal Service

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I. INTRODUCTION

A. RISING THREATS OF BIOTERRORISM, RESURGENCE OF INFECTIOUS DISEASES AND THE IMPORTANCE OF PUBLIC HEALTH

The anthrax and Salmonellaosis attacks in the United States, sarin attacks in Japan, and nerve and mustard gas attacks on the Kurds in Iraq have shown that civilian populations worldwide are vulnerable to terrorist attacks involving bacterial pathogens, lethal toxins, and chemical agents (Torok, Tauxe, & Wise, 1997; Okumura, Suzuki & Fukuda, 1998; Lee, 2003; Tucker, 1996). Reports that the Soviet Union ran the largest covert biological and chemical weapons program in the world have been uncovered (Davis, C.J., 1999). At the same time, several reports stating that military bioweapons arsenals that have been missing since the fall of the Soviet Union and scientists are unaccounted for raise the possibility that terrorists may have access to trained scientist and highly dangerous agents that have been engineered for mass dissemination as aerosols (Alibek, 1999). Instructions for preparing biological and chemical agents are readily available online (Fester, 1997). Biological agents can be highly contagious and fatal, requiring a timely response to avoid economic loss, loss of life and large-scale panic.

A bioterrorist attack of the type or scale described above would likely have a devastating effect on some portion of the U.S. population. Public health response plans are based on mass prophylaxis of their population. In order for LHDs to successfully mass-prophylax their population they would require "… rapid mobilization of public health workers, emergency responders, and private health-care providers…" as well as "rapid procurement, distribution and dispensing of large quantities of drugs and vaccines, which must be available quickly." (CDC Strategic Planning Work Group, 2000)

B. THE STRATEGIC NATIONAL STOCKPILE PROGRAM

Starting with President Clinton's Executive Order 12938 in 1994 the funding for bioterrorism initiatives has increased significantly (Executive Order 12938, 1994). Ten

years later in 2004, President George W. Bush signed Homeland Security Presidential Directive 10 to strengthen the nation's preparedness and defense against the use of biological and chemical weapons (Homeland Security Presidential Directive #10, 2004). This Presidential directive also created a new role for public health within the intelligence community and as a first responder.

The Department of Health and Human Services (DHHS) and the Centers for Disease Control and Prevention (CDC) established the National Pharmaceutical Stockpile (NPS) as a resource for all states and urban areas (Public Health Training Network, 2006). The Strategic National Stockpile (SNS) was created from the NPS as a national repository of antibiotics, chemical antidotes, antitoxins, vaccines, medical equipment and supplies to combat "Category A" Threat Agents as defined by the CDC (Los Angeles County Operational Area, 2005a). At the same time the SNS also contains life-saving equipment such as respirators and N95 masks (CDC - Division of Strategic National Stockpile, 2006). The mission of the SNS is to help state and local jurisdictions prepare a strategic and uniform response to a large-scale natural disaster or an act of terrorism (CDC - Division of Strategic National Stockpile, 2006). States with a small population have the ability to obtain sufficient stockpiles of antibiotics, immunoglobulin, neutralizing agents and antitoxins by directly setting up contracts with pharmaceutical distributors (Public Health Training Network, 2006). Very few states have elected to do so, however, because of the costs associated with maintenance, storage and cycling of expired medications. States like New York and California with large urban populations would have difficulty obtaining a contract for mass prophylaxis of their general populations to begin with.

If a state does establish a contract and order prophylactic supplies from the CDC, the SNS may arrive by ground or by air; its delivery is a federal responsibility and force protection is provided by the United States Marshall Service (USMS). Once the SNS has arrived at a predesignated and secure warehouse (and signed over to the state) the asset becomes a state responsibility. The state would be responsible for distributing the SNS assets to the local jurisdictions. There are designated urban areas like the New York Metropolitan Area, Washington D.C., and the LAC Operational Area where the SNS

assets may arrive directly at the local warehouse (a state representative must still be present to sign for the receipt for the SNS assets). LHDs (City and County Public Health Departments) are responsible for dispensing the SNS assets to the general public (Los Angeles County Operational Area, 2005a).

Since the 2001 anthrax attacks and the influenza season of 2003, combined with the failure of Federal Emergency Management Agency (FEMA), state, and local response efforts during hurricane Katrina, the focus has shifted back from federal response capability to the ability of state and local public health authorities to provide timely and reliable access to prophylactic medications (Jernigan, J., Stephens, D., & Ashford, D. 2001; Webby, R.J., Webster, R. G., 2003). The CDC has therefore called on all states and LHDs to devise a comprehensive mass prophylaxis plan to ensure that the general population has timely access to antibiotics and/or vaccines in the event of future terrorist attacks or natural outbreaks (CDC, 2002).

The CDC created the concept of 'PODs' as a mechanism for dispensing medicine and medical supplies to the general population during a large-scale public health emergency (CDC, 2002). Prophylactic drugs and personal protective equipment (PPE) would be dispensed and vaccines administered at the PODs, or non-clinical sites such as sport stadiums and convention centers. Such an operation at non-clinical sites would ensure that treatment centers would be able to continue treating their existing patients as well as anyone who is symptomatic or injured from the emergency.

Prophylaxis of the entire population should be conducted within forty eight hours, as some agents such as smallpox and strains of pandemic influenza are extremely virulent and contagious; others such as anthrax have a very small incubation period with deaths resulting within forty eight hours (Chen, 2005). Mass prophylaxis within forty eight hours also improves public safety by avoiding or minimizing the potential for riots and civil disorder.

C. OVERVIEW OF THE PROBLEM

PODs are central to an area's emergency response and mass prophylaxis plans, but they are not sufficient and are in fact problematic in many ways. Most major

metropolitan areas have large populations that would require prophylaxis within forty eight hours as required by the CDC Guidance for SNS Planners. CDC does provide an algorithm to determine how many sites would be required during a worst-case scenario, but in heavily populated metropolitan areas the number of sites required for such an operation becomes too large for mass prophylaxis based solely on PODs. This is because it is difficult for emergency planners to find facilities that are not already designated for other functions during an emergency such as a shelter, quarantine, alternate medical facility, etc. At the same time finding a site located in or near heavily populated areas becomes much more difficult. Creating preplans for PODs is very complicated as it requires coordinated input from public health, law enforcement and fire departments to analyze traffic patterns to avoid bottlenecks and gridlocks (something major metropolitan areas are plagued by), finding appropriate parking, access to public transportation and handicap access. PODs are volunteer-dependent and require large staffing capacities in major metropolitan areas.

For these reasons, coordination is critical and at times extremely complicated. Having a large number of PODs strains law enforcement resources due to security concerns, strains the transportation resources that supply PODs with the SNS, which once again adds strain on law enforcement resources as more vehicles on the road means more security vehicles. Finally, the complex structures of government organizations and their relationships with each other and the private sector makes the MOU process very complicated and time-consuming, delaying POD planning and mass prophylaxis plans.

In short, emergency planners in the major metropolitan areas must focus on alternate modes of dispensing to relieve the pressure on PODs if they are to successfully respond to a large scale terrorist attack or face a natural disaster the size of Hurricane Katrina.

D. LITERATURE REVIEW

During the post-9/11 era there is a significant amount of literature available that emphasizes the threat faced by the civilian population in the United States from bioterrorism. This threat became harsh reality after the anthrax attacks using the United States Postal Service (USPS). According to Milton Leitenberg's book, *Assessing the*

Biological Weapons and Bioterrorism Threat, the U.S. military forces found significant evidence that al-Qaeda had spent several years trying to obtain the "knowledge and means of production" to produce biological weapons.

There is very little formally written literature on alternate modes of dispensing. Most studies indicate a clear need to explore alternate modes of dispensing, but most state and local plans do not spell out what these alternate modes are, nor have most of them ever been tested. The most important resource to find alternate modes of dispensing being considered or tested by other jurisdictions has been the SNS List Serve, an online discussion forum where individuals working closely with SNS issues post their thoughts and comments as well as questions.

One frequent problem is that there are no specific guidelines listed by any jurisdiction to formally evaluate the effectiveness of their alternate mode of dispensing. The most that is analyzed is how many people are processed through the system within an hour. This information is quite important, but so is evaluating how it contributes to the POD process, whether it reduces the impact of crowding or the strain on staffing resources, and so on.

A comparative analysis was performed by Mr. Chester Lee Smith to understand how involving business in dispensing of drugs during a mass prophylaxis event would reduce the stress on PODs. The paper compared the use of business PODs, regular PODs, USPS and a combination of all three options using the strategy canvas developed by W. Chan Kim and Renee Mauborgne in *Blue Ocean Strategies*, which allows decision makers to understand "current status of activities to be captured against a range of factors associated with performance within a given industry" visually represented by a value curve (Smith, 2007). This curve shows the relative performance of an option based on the selected factors (Chan & Mauborgne, 2007). Value cures were generated for each of the four policy options being considered.

E. RESEARCH QUESTION

1. How can alternate modes of dispensing be quantitatively evaluated for their efficiency during an event requiring oral prophylaxis?

And

2. Which mode of alternate dispensing would be most efficient in the LAC to address oral prophylaxis of the entire population based on our quantitative analysis?

F. TENTATIVE SOLUTION

The solution to the problems related to prophylaxing a large population identified in the problem statement above is a very practical one: finding alternate modes of dispensing. There are several alternate modes of dispensing that have been tested or planned that could be applicable to other jurisdictions. Some alternate modes of dispensing are very efficient in terms of numbers of people that can be reached, the speed of dispensing and staffing requirements as well as security.

Qualitative analysis cannot directly assess the efficiency of these alternate modes of dispensing, and currently there is no significant tool to quantitatively assess the efficiency of PODs. The first step would be therefore to select successful alternate modes of dispensing and then create a tool to analyze their efficiency in terms of staffing, security and speed/number of people reached.

G. SUMMARY OF ALTERNATE MODES OF DISPENSING

The pre-positioning approach is currently in practice in several jurisdictions and has helped them meet the challenges of procuring resources during an emergency. Having a local stockpile to prophylax their POD staff as well as hospital, fire, EMS and law enforcement personnel and their families could be a huge advantage, since personnel essential during a mass prophylaxis event could be prophylaxed before the SNS arrives. Drugs can be purchased with funds from a number of federal grants, though the local jurisdiction would have to bear the cost of rotating the drugs (Public Health Training Network, 2006). This process is being used in LAC with great success.

The health department in Orange County, Florida, seems to have had great success with its business PODs, with which it plans to prophylax 40% of the population. Memoranda of Agreement (MOA) with large employers would ask employers to prophylax their own staff and families of staffs (Crow, 2007a).

The Sheltered in Populations (SIPS) plan tested in Oklahoma has been very successful. The plan targets populations in jails, assisted living facilities, nursing homes and hospice who may be unable to come to PODs. During the exercise personnel dispensed 50,000 doses in three hours using only nine nurses and minimal security. The success has been so great that Oklahoma City/County Health Department is planning to expand the program in phases to include other groups, such as colleges and universities that had initially been left out (Public Health Training Network, 2006).

The city of Las Vegas is, like Los Angeles, a high-priority target. The city of Las Vegas plans to deliver medication to hotels, which seems to be a very reasonable strategy (Aherns, 2004). Las Vegas must, for obvious economic reasons, be able to care for its large tourist populations. MOAs have been signed between the resorts and the health department, but the plan has not been tested as it has been difficult to close a section of a resort for an exercise.

Denver, Colorado, has built a successful relationship with Kaiser Permanente, through which Kaiser would operate PODs using its staff to prophylax all staff members and their families. Kaiser organizes drive-thru flu clinics during the flu seasons and it therefore has experience dealing with PODs. This approach alleviates significant pressure from other PODs.

The most important discussion for rapid delivery within forty eight hours has been around the use of USPS employees. The USPS has route information and delivers mail to virtually every household in its assigned area daily (GAO, 2004). This makes it the most efficient alternate dispensing option when the agent is anthrax and the only prophylaxis is doxycycline. An agreement is already in place between the USPS, Department of Homeland Security (DHS) and the DHHS for USPS workers to deliver medications door-to-door during an emergency (Los Angeles County Operational Area, 2005b). However, the USPS's 1:1 security demand has held up planning in several jurisdictions. For example, in the State of Rhode Island where crime and mob rule is relatively low, the terms of such a contract are easy to agree upon; in Los Angeles, where there is a history of crime and riots, the postal workers union demands one-on-one protection for all postal workers.

A popular concept has been drive-through PODs. Originally when the idea of using them emerged from the Hawaii State Exercise in 2004 it received a lukewarm response. But since the application of this strategy to drive-through flu clinics, it has been the leading alternate mode of dispensing after alternate delivery. There are still critics on both sides of the debate, however: for example, the influenza exercise in Colorado was successful and it was quickly decided that a drive-through POD would be a part of any alternate dispensing strategy (Lehman, 2004). On the other hand, in Ohio the drive-through clinic led to a huge traffic back-up (Iiames, 2004).

Dr. Onora Lien interviewed executives from various grocery stores, retail pharmacies, and wholesale chain pharmacies, and they unanimously endorsed the idea of planning for and responding to a bioterrorist event. Although these chains are for-profit companies they identified a strong bond with their community: "Nearly all retail executives acknowledged that doing the 'right thing' for the community and the nation would be the 'right thing' for their business in the long run." (Lien, 2006)

H. METHOD

MAVF is an approach that supports multiple criteria decision-making by taking into account the trade-offs a decision-maker is willing to make between attributes (Belton, 2002). The process reveals and documents decision-makers' preferences and easily determines their points of disagreements; at the same time it can perform marginal and sensitivity analysis rapidly under a variety of scenarios.

Identification of the measurable criteria that would define a strong alternate dispensing option is critical for successful analysis. Most alternate modes of dispensing fall into one of two categories: modes that dispense to the general public (Model A) and modes that dispense to a specific subset of the general population (Model B). In the former model, speed is an important attribute replaced in the latter model by the number of people that can be reached (since the mode would have a finite cap). Assessment of security and staffing requirements are common to both models. Staffing is assessed as percent staff reduction by comparing the staffing requirement of the option to that of the baseline (POD staffing in a given jurisdiction). Percent staff reduction has two sub-components, percent clinical staff reduction and percent non-clinical staff reduction.

Security assessment is determined by a committee of experts in mass prophylaxis and security on a scale of 1-10, where one is the lowest security requirement and ten is the highest. The security assessment has two sub-components, site security and transportation security. All three criteria influence the final decision as to which alternate mode of dispensing is most viable. For example, an alternate dispensing option may be very efficient in terms of its speed but may have very high security demands, making that option unavailable.

The weights for each criterion to analyze a decision maker's preference are set by a committee comprised of experts from Public Health, Emergency Medical Services (EMS), Law Enforcement and Fire Departments.

Decision makers must list all possible alternate modes of dispensing they plan to analyze and describe in significant detail how each mode may be implemented in their jurisdiction. The data for each alternate mode of dispensing are collected through careful review of journal articles, attendance at exercises as evaluators, after-action reports and information available online. The information is entered into an Excel spreadsheet along with assessed weights to perform MAVF. The Excel tool will provide a quantitative basis for selecting an alternate mode of dispensing, though it does not account for political/external complications present in the metropolitan area.

I. SIGNIFICANCE OF RESEARCH

With the rising threat of bioterrorism the nation needs to be prepared for a mass prophylaxis response. The CDC's model of mass prophylaxis states that PODs will be the cornerstone of any operation, but the CDC also admits that in a worst-case scenario PODs will not be enough, and alternate modes of dispensing would be required. Several public health jurisdictions at state and local levels have invested time and resources designing alternate modes of dispensing tailored for their population and based on available resources. However, there are no concrete overarching studies that analyze speed of dispensing, total numbers that can be reached in forty eight hours, staffing requirements, cost and security for various alternate mode of dispensing through formal statistical analysis. This research will rely on a multi-objective decision analysis, a well-established tool in decision analysis and operations research, to analyze which alternate

mode of dispensing would be the most valuable during a mass prophylaxis event. The study's primary audiences are local and state SNS and Mass Prophylaxis coordinators as well as SNS reviewers/advisors at the CDC and DHHS.

J. OVERVIEW OF CHAPTERS

This thesis is organized into ten chapters to address this policy question. This chapter has provided an overview of the importance of Public Health in bioterrorism events, the background of the SNS, an overview of the problem, a review of literature related to the problem, a tentative solution, a summary of alternate modes of dispensing, a discussion of the methodology, the significance of the research and the overview of chapters in the thesis. Chapter II provides an in-depth analysis of the problems facing the POD-based approach to mass prophylaxis, and looks at problems associated with exercise data, finding suitable POD sites, challenges related to staff procurement, coordination, training and care for their families, security challenges, traffic control challenges, issues related to dealing with special needs population and cyber security. Chapter III provides a description of the POD-based approach and nine alternate modes of dispensing. Chapter IV provides the methodology used to analyze our modes of dispensing. Chapter V provides an overview of the geo-political structure of LAC and then applies the model described in Chapter IV to LAC and explains how numbers were derived. Chapter VI provides the results of our analysis. Chapter VII discusses the uncertainty of data in Model A and Model B and determines that the results obtained in Chapter VII are robust and applicable. The chapter also provides a discussion on the acceptability of results, pitfalls that LHDs must consider as they develop portfolios of various options, considerations with respect to the special needs population, and ensuring that the gaps left behind by the POD-based approach are addressed by the alternate modes of dispensing. Finally, this chapter identifies barriers and solutions to implementation of the results, provides a scope for future research, and presents the conclusion of this research.

II. POD-BASED DISPENSING AND CHALLENGES

A. TRADITIONAL MODES OF DISPENSING - THE PODS

The POD-based approach was created by the CDC to ensure that prophylactic medications were dispensed to the community safely. PODs typically serve three major functions: They prevent the hospital system from becoming overwhelmed; they separate the symptomatic individuals from the general population under medical supervision; and they can bring together a large number of people for mass prophylaxis so that scarce resources such as staffing and security can be concentrated at designated locations (Hupert, 2004). The DHHS introduced the PODs approach as the most fundamental approach to mass prophylaxis. PODs have two modes: "OPEN," providing prophylaxis to the general population as seen during exercises such as TOPOFF 3 in New Jersey, or "CLOSED," providing prophylaxis to a specific segment of the general population, as in New York in the aftermath of the anthrax attacks (Government Accountability Office, 2004).

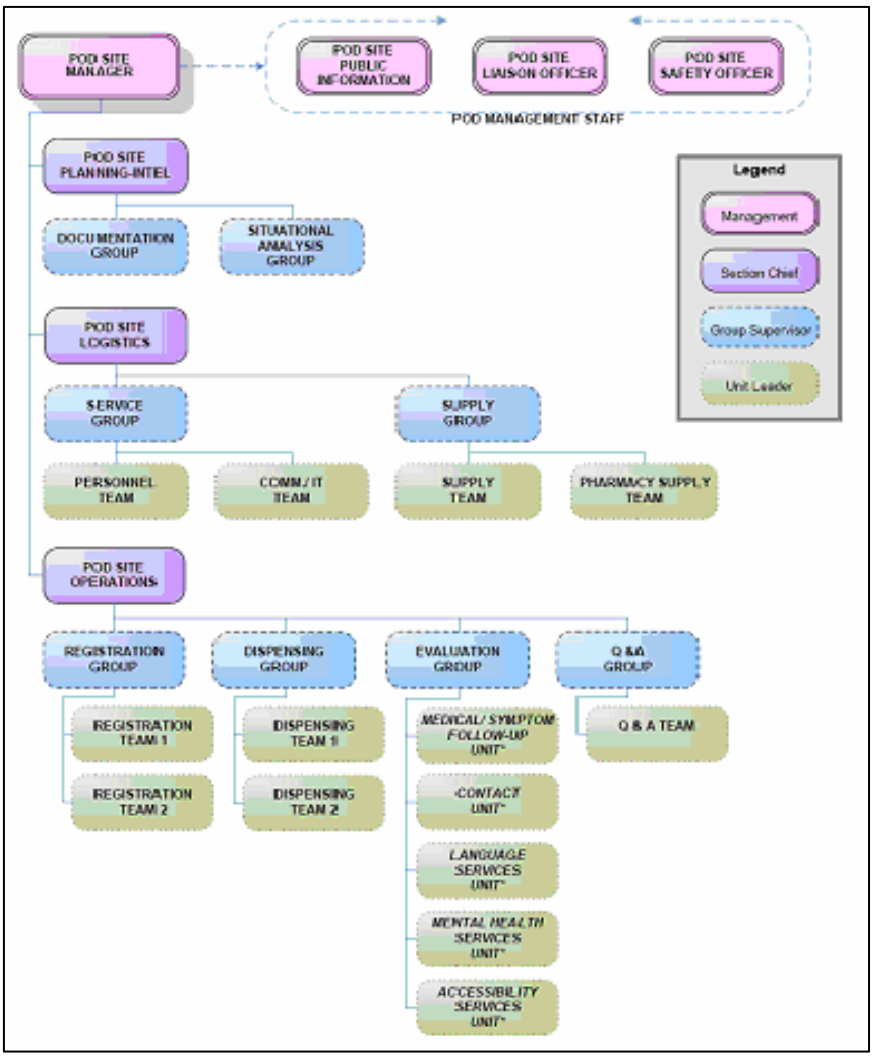
The CDC recommends that PODs be sites that the community is familiar with such as sports arenas, convention centers, community centers, and, in some cases, schools. This is because they are usually located in areas with high population density and easy access, ample parking, and close to public transportation facilities (City of Los Angeles, 2006). These sites are typically climate controlled. Local law enforcement is usually familiar with them and has practices to securing them. Facility preplans that denote all major rooms, entrances and exits as well as the site layout during the POD operations should be laid out in advance. Unless a facility is owned by LHDs, they would require a memorandum of understanding (MOU) with the facility owners to ensure that the facility will be available during an emergency.

Core operations at a POD, as recommended by the Weill Medical College of Cornell University, involve greeting, forms distribution, triage, medical evaluation, transportation assistance, transportation assistance, mental health evaluation, briefing, dispensing and form collections (Agency for Health Care Research and Quality, 2006).

These are called core functions as they directly influence dispensing of drugs. Support functions at PODs include drug re-supply, line monitors, data entry, translation services, IT support, food services, facility maintenance and security (Agency for Health Care Research and Quality, 2006). However, the number of functions performed at each POD will depend on the availability of staff and needs of the target population. Some functions may be performed in conjunction with others at a single station. There are several clinical layouts that have been established by the Weill Medical College of Cornell University's Department of Public Health (DPH) (Hupert, 2004). The clinical layout chosen by each jurisdiction would depend on the targeted flow rate, staff availability, security availability and the physical layout of the POD site itself.

POD communication and management would be based on the Incident Command System (ICS). There are several advantages to managing a POD using ICS principles: it enforces the use of common language and it reduces duplication of work and improves efficiency (State of California, 2004). Each site would be required to have a designated POD site manager, a public information officer, a safety officer, and liaison officer. These individuals form the POD management staff (State of Califorina, 2004). The running of a POD requires two types of personnel – medical staff responsible for dispensing and non-medical staff responsible for support functions. A summary for this structure for LAC is provided in Figure 1 (Los Angeles County Department of Public Health, 2007).

Figure 1. Points of Dispensing – Incident Command Structure. Originally published in the Los Angeles County Mass Prophylaxis Plan.



Estimating staff requirements for all these functions is challenging. The Bioterrorism and Epidemic Outbreak Response Model (BERM) version 2.0 recently created by researchers at the Weill Medical College of Cornell University helps planners predict the total number of staff and the number working in each work group required for a successful mass prophylaxis campaign for a given population. The software allows the selection of population size, duration of the campaign, number of shifts and hours of operation, type and scale of the event, and the anticipated flow rate, and provides estimates of support and core staff required at each site. The system also allows the

planner to limit the staffing input and see the estimated effects it would have on the POD campaign. Using these estimates, planners should test their POD staffing and throughput model to obtain accurate staffing estimates.

B. CHALLENGES FACING POD BASED MASS PROPHYLAXIS

In its third annual report, *Ready or Not? Protecting the Public's Health from Disease, Disasters and Bioterrorism*, the Trust for America's Health determined that we are significantly under-prepared to respond to a bioterrorism event in the United States. The panel noted that 85% of states received a score lower than six on a 1–10 scale; the federal government also received a failing grade as related to activities dealing with bioterrorism preparedness and response (Trust for America's Health, 2006). Public Health agencies were put in charge by the federal government to lead bioterrorism preparedness and response activities. But as seen during the smallpox campaign, there was a shortage of medical personnel to mass-vaccinate the public during an emergency (Mitchell, 2005). This was because Public Health agencies do not have the infrastructure required for mass prophylaxis (Santiago, 2006).

Comprehensive mass prophylaxis plans are based on PODs, which would serve as a mechanism for dispensing medicine and medical supplies to individuals in the area of risk during a large-scale public health emergency. Mass prophylaxis coordination requires advance planning and integration of staffing, security, traffic and control plans to successfully respond to the incident (Whitmore, 2005). Each of these processes is interdependent and affects the efficiency of the others. For example, if POD throughput is not fast enough due to insufficient staff, then security will be at risk of being overrun, there will be a gridlock in the parking lots and an overflow of traffic on access roads that will limit the ability of clients to get to the POD.

While the official standard for mass prophylaxis is PODs, there has been much discussion of their potential failure modes. Practically all exercises done using PODs proclaim themselves wonderful successes. While this is not an unexpected result given political pressures, it hides many potential issues that may negatively impact how well a county is able to meet prophylaxis standards in actuality. This chapter presents highlights

of some of the difficulties. When alternate modes of prophylaxis are considered, they should be chosen so as not to worsen these situations or duplicate the same failure modes.

1. Problems with Exercise Data

Several exercises in the U.S. have tested POD models. However, most of these exercises have been functional exercises that test only a single component of mass prophylaxis. All exercises are very well-planned, using professional contractors who provide scripts of a predetermined agent and sufficient and pre-designated POD staff who are generally trained in advance. Exercises are often criticized for not introducing "surprise elements or contradictory information" to analyze reactions of the POD staff and managers (Lioy, 2005). Exercises typically have a limited number of people being rotated through the POD on a continuous basis for a few hours. During an event, LHDs may not have pre-trained staff and they may not work efficiently throughout a twelve-hour shift. People coming to the site will be confused, concerned and anxious and may not be compliant. Therefore the throughput obtained from the exercises may not represent throughput during an actual event.

Most exercises do not provide accurate estimates on the set-up period prior to POD operations. Precisely because exercises are well planned, it becomes very difficult to anticipate the time requirement from identification of an agent to assessment of the impact, and activation of mass prophylaxis plans to set-up of the PODs, organization of staff and launch of mass prophylaxis.

Exercises also fail to capture the sense of chaos among the general public and fuelled by the media; above all, they fail to capture how an agency would locate and organize its staff and volunteers amid the brewing chaos (Lioy, 2005). Finally, POD exercises often lack a security component as it is hard to justify full security staffing for an exercise.

POD operations require coordination and robust communication between PODs, the Receipt, Store and Stage (RSS) Warehouse and the Command Center to assess the

need for resources. But it is very rare that all three components are exercised at the same time. It is hard to test communication at exercises due to a casual approach by POD staff during exercises (Lioy, 2005).

2. Finding PODs

CDC recommends that PODs have very specific physical characteristics (City of Los Angeles, 2004). Based on these recommendations there may not be enough sites within the geographic boundaries of a LHD to serve as PODs. Difficulties may still arise due to the social stigma attached to bioterrorism events or liability issues for damage to the facility.

3. POD Staffing Challenges

Due to state and local budget constraints most LHDs are understaffed to run their daily functions (Flynn, 2004). Exactly how many staff are needed is unknown, as demand at each site is variable and unpredictable. Models suggest large staffing requirements, making the process completely dependent on volunteers (Trust for America's Health, 2005; Los Angeles County, 2006).

a. POD Staff Procurement

Since mass prophylaxis is volunteer-dependent, staff procurement becomes a troubling issue. The forty-eight-hour deadline to prophylax the entire general population puts a heavy burden on PODs, especially when LHDs estimate they would require at least twenty four hours to contact and recruit their POD staff and set up POD operations and security. This puts great constraint on the time available to procure volunteers. The POD staffing resources consist of volunteers and staff from various departments within the local agency as well as other partner agencies. For example, a county will use its own staff as well as staff from cities within its boundaries; this in itself could lead to staffing complications unless there is marked delineation of duties between cities and the county (Los Angeles County Operation Chimera, 2005a). Nevertheless, a large percentage of PODs would be volunteer-driven and getting a workforce large enough to staff PODs for two twelve-hour shifts per day could become challenging.

Most LHDs concede that they will not be able to set up and operate all PODs at once and PODs would be opened based on availability of staffing and security resources. This would once again put great strain on PODs already open as people from neighboring and distant cities may pour in to obtain prophylaxis.

LHDs need to set up registries that can register, credential clinical staff and ideally train POD staff, a time-consuming and expensive process. Choosing not to do so could divert crucial resources required for mass prophylaxis during an event. Spontaneous volunteers arriving at PODs would add to the traffic congestion and would negatively influence POD operations. Maintaining updated staff call-down procedures and designating a reporting location such as a staging area will help, but may not be adequate because of uncertainties to do with travel impediments or personal obligations.

b. POD Staff Coordination

Coordinating spontaneous volunteers and LHD staff with PODs based on shifts and needs should be well coordinated. The lack of a pre-planned staging area for staff to gather can result in "flocking" at undesirable locations, such as PODs, hospitals and other healthcare facilities (Los Angeles County Operation Chimera, 2005b), resulting in compromised care, uncoordinated staffing efforts, and over- or under-staffing. This makes a strong case for a staging area for personnel (City of Los Angeles, 2004). The need for coordination would dip into valuable resources as a staging center itself would require staffing and security.

Planning breaks for staff and changing shifts should be well coordinated in order to prevent disruption and thereby slow down throughput.

c. POD Staff Families

Public health agencies are sending a mixed message to potential POD staff. The general public is told to come to PODs to receive prophylactic treatment within forty eight hours, indicating a significant threat to public health. POD staff, to the contrary, are told they can take medications back to their loved ones after a twelve-hour shift at a POD. This conflicting message creates a huge dilemma for volunteers who are

told they will receive medications for themselves and their families if they work at a POD. It may be much more expeditious for the potential volunteer to go to a POD and stand in line for up to four hours to obtain medications for themselves and their families.

There may be problems associated with the willingness of POD staff to stay for a twelve-hour shift, and this is not isolated to volunteer staff. The staff belonging to LHDs – as well as other city and county staff - may also be unwilling to stay at a POD for a twelve-hour shift because of dependent care obligations that PODs themselves would be unable to meet (Trust for America's Health). POD staff will not report for duty unless they have been assured that they and their families are safe; anything less will result in staffing shortages and absenteeism.

d. POD Staff Training

POD volunteers would require "just-in-time" training in communication, ICS and the POD process. Training staff on the use of radios and understanding ICS takes time, but not doing so would lead to a breakdown in communication (Los Angeles County Emergency Preparedness and Response Program, 2006). A lack of familiarity among volunteers with the chain of command established under ICS can lead to delays, as they do not understand how to report problems through proper channels and how to order supplies (Los Angeles County Operation Chimera, 2005c). A breakdown in communication can result in duplication of efforts; resource requests and gaps in operations affect the efficiency of PODs, resulting in a slower throughput (Los Angeles County Operation Chimera, 2005b).

Since POD staff receives only just-in-time training for the POD process, misunderstood instructions can lead to disruption of POD operations. However, increasing the time spent on such training can result in delayed opening of PODs. The CDC-developed algorithm used during triage is complicated and requires time to properly understand it and be able to implement it. Computer-based systems like the inventory management system or patient tracking systems require advance training. Although all PODs in a given jurisdiction may have a standard floor plan, the entry and exit points as well as queuing and setup of stations may be different from site to site.

When POD staff arrives for their shift there may not be enough time to familiarize them with the POD setup and operations during an emergency. Without a clear understanding of the POD flow, layout and set up valuable time is wasted, affecting POD efficiency.

In case of a contagious disease it may be very difficult to properly train POD staff to adhere to PPE compliance guidelines. POD staff may feel uncomfortable wearing them or choose to wear them sporadically (New Jersey Domestic Security Task Force, 2005). Fit-testing each staff with PPE may also pose a challenge as it can be time consuming, but not doing so could potentially put them in harm's way and discourage others from volunteering.

4. Security Issues

A major strength of PODs is that they bring a large number of people together for rapid prophylaxis to a few designated locations; this is, ironically, also their potential vulnerability. After a bioterrorism event there is an atmosphere of uncertainty and confusion. Since PODs are large facilities that will attract a large number of people, they can be optimal targets for terrorists. A bombing at such a facility would cause a large number of fatalities from the initial attack and many more during the stampede that would follow as people tried to flee the facility. PODs could become the secondary targets; since they provide terrorists with an "optimal" combination of mass casualty and mass media exposure, they should therefore be considered a high-value, high-payoff target (Los Angeles County Operation Chimera, 2005d). An attack at such a facility would discourage potential staff from volunteering to work at PODs and discourage people from going to them. POD security also faces internal threats from gang activities (rival gangs meeting at a POD), people cutting in line and general public insubordination, which could lead to rioting.

The cumulative needs of securing several POD locations, local hospitals, and a panicked public will stretch the combined strength of all law enforcement to its limit. Officers remaining would also be required to perform daily law enforcement functions

such as conducting criminal investigations and maintaining civil order. It is possible to get military support, but it may take National Guard troops up to two days to arrive (Mitchell, 2005).

Several SNS plans have determined that because of the potential for panic and civil disorder as well as the perception of having a limited supply of pharmaceuticals available to the public, security at PODs is critical and it would be most effective if a single agency were responsible for coordinating this function (Los Angeles County Operation Chimera, 2005a). However, in larger counties such as Los Angeles, the several major police departments and County Sheriff's department would need to coordinate and put aside politics for the duration of the campaign.

5. Traffic Control

Since PODs are generally large facilities and located within population centers there are obvious traffic control considerations – this is especially the case in geographic areas without significant mass transportation systems and a high population density. Roads could be overwhelmed with a large number of cars converging on the location. Managing parking would also be a challenge and security would be required in parking lots to prevent potential conflicts. People walking through parking lots also pose a challenge as this can lead to accidents that slow traffic and require ambulance response. LHDs require strong traffic control plans to manage the events outside the POD to ensure that operations inside run smoothly.

6. Special Needs Population

There is a debate about how PODs should deal with the special needs population. People with special needs may not be able to wait in long lines for hours to receive their medications and may not have a family member to do it for them. If they are placed in regular lines this could adversely affect throughput. Some LHDs have suggested moving them to the front of the line but that could lead to conflict with people already waiting in long lines. Others have suggested having a special line for delivery to special needs, but this may lead to ethical violations. Critics of both approaches believe that LHDs are placing too much emphasis on these minority populations (Lioy, 2005). Nevertheless, a

lack of equal care can result in psychological damage to the community and disruption of POD operations, and open LHDs to legal actions (Los Angeles County Operation Chimera, 2005c).

Due to these problems it is vital that LHDs explore alternate modes of prophylaxis to supplement the PODs. The alternate modes of dispensing need to be able to address the shortcomings of the POD without exacerbating the issues highlighted in this chapter. The identification and evaluation of such options is the focus of the next chapter.

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III. ALTERNATE MODES OF DISPENSING

Many LHDs find it extremely difficult to prophylax their entire population within forty eight hours using only their PODs because of staffing, security and site availability concerns. LHDs could open more PODs but this would not resolve the issue because the number of PODs is directly correlated to the requisite number of resources. LHDs could increase the throughput at each site but this has the same limitations, as the throughput is directly correlated to the amount of resources required. Considering that resources will always be under pressure it becomes necessary for Public Health officials to consider alternate modes of dispensing (Public Health Training Network, 2006).

Although the DHHS still views PODs as the cornerstone of dispensing during a bioterrorism event requiring oral prophylaxis, additional alternate methods of dispensing would be required to prophylax the entire population of a larger jurisdiction within forty eight hours. This is because PODs are limited by resource availability and during an emergency LHDs may not be able to acquire all resources they need to prophylax their population fast enough. Alternate methods of dispensing are meant to complement PODs as they reduce the number of people who need to be moved through PODs (Public Health Training Network, 2006). The CDC recommends several alternate modes of dispensing that have shown to be best practices and there are several other alternate modes of dispensing that are regularly discussed on the SNS listserv hosted by the CDC. Nine major alternate modes of dispensing will be discussed in this paper; some are based on the "pull" model (people must come to a given location to collect their medications) and others on the "push" model (prophylactic medications are pushed out to where people are located). The CDC states that in order to create a robust alternate mode of dispensing LHDs need to first identify the population that it would serve, research the availability of resources, and create a strong partnership with stakeholders (Public Health Training Network, 2006). Since the problems associated with alternate modes of dispensing are unique, they are best analyzed for their efficiency at the local level.

A. PRE-POSITIONING OF MEDICATIONS

The pre-positioning approach is currently in practice in several LHDs and has helped them to meet the challenges of procuring resources during an emergency. Having a local stockpile to prophylax POD staff as well as Fire, EMS and Law Enforcement personnel and their families could prove to be a huge advantage because personnel required for mass prophylaxis could be prophylaxed before the SNS arrives. This indirectly helps the entire community because response staff would be ready when SNS arrives. This ensures continuity of government and at the same time serves as an incentive for jurisdictions receiving prophylaxis to send their employees to work at PODs (Public Health Training Network, 2006). Pre-positioning will also prophylax a large subset of the population and keep them away from PODs. In this study we will consider two different types of pre-positioning practices: one for government employees, defined as those (including contract employees) working for local (county or city) governments and their families, and pre-positioning for hospital patients, staff and families of staff members. The number of bottles received by staff for their family members would be determined by the median family size in the jurisdiction.

Prophylactic drugs can be purchased using funding from the Urban Area Security Initiative (UASI) or Metropolitan Medical Response System (MMRS) to stockpile medications for first responders; funds from CDC can be used to purchase drugs for public health emergency response personnel; and funds from the Health Resource and Services Administration (HRSA) can be used for hospitals. The first responder population includes Law Enforcement, Fire, EMS personnel and "all people that have been identified in helping in some form or another with decision making, security or public health response during an actual event (Public Health Training Network, 2006)."

The most important step in setting up a pre-positioning operation is to coordinate plans between LHDs and other local government agencies and hospitals. Medications could be stored at government offices and hospitals or they could be stored in a centrally located warehouse under the control of the health department. LHDs must provide clear guidelines as to what the responsibilities are of each agency receiving the medications. The LHDs would be responsible for writing and managing grants and ensuring that the

drugs are rotated before they expire. If the drugs are pre-deployed then it would be the responsibility of the agency accepting the drugs to maintain their cache under strict supervision of the LHD. No agency would be allowed to distribute drugs without the consent of the Public Health Officer of the LHD. If the drugs are located at a central warehouse it would be the responsibility of the LHD to maintain the cache; the partner agency would be responsible to pick up and dispense the drugs during an emergency. A signed MOU would be required between agencies detailing the maintenance of the cache and the requirements and responsibilities of both agencies. LHDs would be responsible for ensuring compliance with the policies of the program and would therefore need to create a registry for all personnel working for each partner agency. The registry must include all locations of the drugs, the amount of drugs and contact information of the personnel responsible for dispensing at the partner agency.

Setting up a pre-positioning system can be time-consuming, as it requires buy-in from many partner agencies to offer a significant advantage over PODs. But the security requirement for pre-positioning is generally deemed as low, the time required to prophylax first responders and their families is minimal and it can significantly reduce bottleneck at PODs (Public Health Training Network, 2006). The option requires no staff from the LHDs during an emergency if the drugs are pre-positioned on-site or very little staff if the drugs are located in a central warehouse. It is essential that first responders including POD staff know that they and their families are being taken care of to ensure a successful and efficient response.

B. DISPENSING MEDICATIONS AT BUSINESSES

The federal government has gone to great lengths to encourage businesses to create a Business Continuity Plan. Businesses can expect huge losses, as seen during the SARs outbreak, when a significant disease terrorizes the general population. People may refuse to go to work and choose to go to PODs to pick up medications for themselves and their families instead. Many LHDs see businesses as an untapped resource (Public Health Training Network, 2006). If LHDs can convince large employers to prophylax their own employees and their families, it will keep employees at work so business can continue. This is of clear benefit to the private sector, but it would also reduce the

pressure on PODs by reducing the number of people who need them. It is important that LHDs try to target large employers and those that deal with critical infrastructure such as power, water and communications. The LHD in Orange County, Florida, has had great success with their business PODs. The challenge for the jurisdiction is to prophylax 1.6 million people in Orlando within 48 hours. After establishing MOAs with large employers and medical facilities to prophylax their own employees and their families, the department estimates that they can prophylax 40% of their population without recourse to their POD (Crow, 2007b).

A business POD would require an MOU between the LHD and the private sector partner that will specify the roles and responsibilities of both agencies. It would be the responsibility of the LHD to notify business partners about the activation of the dispensing plan, separate and repackage medication that will be allotted to each business, create and send forms, as well as notify a responsible party regarding the location (the distribution site) and pick up time for the prophylactic medications. The health department would also be responsible to train key personnel to provide just-in-time training to the business POD staff. Businesses would be responsible for picking up and dispensing drugs to their employees with proper medical oversight, distributing forms and information sheets to their employees, setting up and staffing a business POD and returning all unused items along with completed patient forms back to the department of health (Crow, 2007b). After an MOU is signed, the LHD would issue an authorization letter to the businesses, and the person responsible to pick up the medications would have to bring this letter along with photo identification in order to gain access to the distribution site.

Once the decision to activate the Business POD dispensing plan is made, the LHD will notify their point of contact at each business and ask them for the total number of employees on their payroll and give the time and location for pick up of their medications. A distribution site would be set up to distribute drugs to businesses. The company point of contact would either arrive at the site or send a representative with the letter of authorization to pick up the medications. This representative would be responsible for taking the medications back to their business POD. Medications would

be dispensed to all employees who would also receive prophylactic drugs for their families. Large businesses typically have occupational health nurses on staff to oversee issues such as workers compensation and therefore provide medical oversight; they may in some cases choose to contract their employee health services from an outside agency such as an industrial health clinic or a medical consultant firm to come in during an emergency and provide for medical oversight of dispensing. Nevertheless, businesses may be unable to locate medical staff to provide proper dispensing oversight. In such a case, businesses would ask employees if they have any relative who has a medical license – such as a nurse, doctor, pharmacist or dentist – and would be willing to take responsibility of medical oversight during dispensing. In the worst case scenario, the LHD would provide medical staff for medical oversight. However, the goal of this alternate mode of dispensing is for the LHD NOT to deploy any medical personnel.

Efficient business continuity is essential to preventing heavy economical losses during a disaster (Linder, 2004). Incorporating business PODs in mass prophylaxis planning would be a giant leap forward to strengthen recovery efforts for all parties. Employees would return to work faster and LHDs can reduce pressure on PODs and their staffing/security resources.

C. DISPENSING TO SHELTERED IN POPULATIONS

The Sheltered-in Populations (SIPs) are typically defined as the populations that cannot make it to a POD at all, or only with great difficulty. If they do go to the PODs with great hardship, they may be unable to stand in long lines for an extended period of time and could slow throughput. SIPs are particularly vulnerable as they require special care from staff at the facilities where they are located. As seen during Katrina, the sheltered-in population residing in nursing homes, group homes and assisted living facilities can easily be victimized when staff abandons their facilities to care for themselves and their families (Public Health Training Network, 2006).

A very successful SIPs plan was developed in Oklahoma by the Oklahoma City/County Health Department. The plan targeted jails, nursing homes, group homes, residential care, hospice, and home health care facilities, required minimum staffing and security and could still serve a significant portion of this population. The program also

developed relationships with meals-on-wheels programs to distribute medications. Although most of these facilities are required by law to have medically licensed staff on hand, there are some that do not. In the latter case the health department looked to family members of the resident or a family friend that had a medical license and was willing to take responsibility for the given facility and in every case found a representative (Public Health Training Network, 2006).

The biggest challenge that Oklahoma City encountered in setting up its SIPs dispensing plan was the creation of a registry, because finding their target agencies was very challenging. The Oklahoma City/County Health Department worked closely with state agencies that were involved in licensing, other agencies that deal with the target population, and even resorted to using the phone book. The registry included all locations of the target population, the number of people living there and the number of staff working there along with the members of their immediate household. They also identified a single primary and two secondary points of contact during an emergency to be notified of the location of the SIP site. These contacts were required to be a licensed medical professional (Public Health Training Network, 2006). The LHD would issue an authorization letter to each participating agency after an MOU had been signed. The primary points of contact would be called during an emergency and notified about the location and time where they could pick up their medications. The primary point of contact or a designee would bring the authorization letter and a photo identification to pick up the drugs for the facility. The designee would be given the drugs and forms to be filled out for each patient and returned to the LHD. It would be the responsibility of this representative to dispense the drugs to the resident population at their facility (Public Health Training Network, 2006).

There have been several challenges that Oklahoma City/County Health Department had to overcome during the initial phases. The most important had to do with engagement of the higher level personnel at each agency, who were reluctant at first because they were under the impression that their in-house physician could provide the

drugs needed during an emergency. A secondary problem down the road was keeping the registry updated, due to a high turn-over rate at the targeted facilities (Public Health Training Network, 2006).

Today the SIPs plan has been tested in Oklahoma and has been very successful. There were 150 facilities in their registry providing prophylaxis to 250,000 people in Oklahoma County in 2006. During an exercise 50,000 doses were given out in three hours using only nine dispensing staff members and minimal security. The success of the SIPs plan has been so great that Oklahoma City/County Health Department is planning to expand the program in phases to include more groups (Public Health Training Network, 2006).

D. DISPENSING TO STUDENTS AT COLLEGES AND UNIVERSITIES

There are approximately 16 million students attending colleges and universities in the United States today (University of Colorado, 2007). Several major metropolitan areas such as Boston, New York and Los Angeles have a large number of colleges and universities with a large student body. College and university health centers in the United States provide low-cost primary health care to 80% of students nationwide (Patrick, 1988). There are no federal requirements for universities or colleges to have a health center on campus but most do (Patrick, 1988).

Student health centers at colleges and universities are usually staffed by Nurse Practitioners, Registered Nurses or Physicians Assistants. Some universities have medical doctors on staff while smaller institutions maintain a part-time relationship with local doctors to staff the health center during certain hours. Research universities may also have faculty that are medically licensed to dispense medication and thus can provide oversight for the dispensing process (Education Encyclopedia, 2002). Colleges and universities have the infrastructure (large open space for dispensing such as auditoriums or basketball courts), medical staff, and non-clinical staff in the form of teachers as well as the student body required to run a POD.

The university/college POD would be a closed POD for students, staff and faculty with valid institution identification. LHDs must ensure that a university or college has a proper location to set up the POD and conduct a security assessment to make sure that the

area can be secured by university police or the local law enforcement agency. LHDs must also verify the clinical and non-clinical work force available to run a university/college POD and the number of students attending the institution. Universities with an extremely large student body may require additional clinical staff from the LHDs to prophylax within the forty-eight-hour timeframe. A mandatory MOU between the college or university and LHD would articulate the roles and responsibilities of each. Following the activation of the plan, it would be the responsibility of the LHD to notify the colleges and universities and obtain essential information regarding student and faculty numbers. Since some large universities with multiple campuses have a transportation system, they would therefore have the drivers and resources to pick up medication from a designated location and deliver them. Those without transportation assets could request resources from campus police or the LHD. It would be the responsibility of the university to set up, staff and operate a POD with guidance available from the LHD. It would be the responsibility of the university/college to return all filled out forms and unused assets to the health department. Since some colleges and universities are state-run, LHDs must consult their state board of education as well as the university management during early stages of planning.

There is debate whether to allow students to pick up medication for their families, since university staff and faculty would be allowed to do so. The main argument against this is that college students may be from out of town or living in student housing – in other words, away from their families. However, at community colleges students are typically local and reside near their families. This issue must be resolved by each jurisdiction at early stages of planning.

Colleges and universities are capable of providing the infrastructure to support mass prophylaxis that includes site, staff and in some cases security. Prophylaxing students, faculty and their families will significantly reduce the pressure on PODs, and LHDs may also be able to recruit students as volunteer staff members.

E. DISPENSING TO RESIDENTS AT MAJOR HOTEL CHAINS

Most major metropolitan areas such as Los Angeles, Las Vegas, and New York not only have large local populations but must also deal with a fluctuating population of

tourist and business travelers. It may be extremely difficult for this population to locate PODs as they may not be familiar with the surroundings. However, LHDs must still prophylax this surplus population within forty-eight hours.

The Southern Nevada Health District (SNHD), which includes Las Vegas, adopted a unique solution to deal with its fluctuating population as Las Vegas has over 300,000 tourists on peak days (Public Health Training Network, 2006). The SNHD partnered with hotel and resort chains to set up closed PODs to prophylax employees and their families as well as all guests. This partnership was successful as it lowered economic loss for the hotels and resorts and at the same time prophylaxed the fluctuating and local population.

To make such a plan operational an MOU between the LHD and the hotel and resort chains would be required. It would be the responsibility of the LHD to provide the hotel chains with proper forms, medications, and training to key personnel involved in the dispensing process. It would the responsibility of the hotel and resort chains to set up and run the POD and provide all medical and non-medical staff required for dispensing; they would also have to demonstrate the availability of space and staff before the MOU could be signed. Hotel and resort chains often have an occupational nurse on staff for issues such as workers comp or may choose to contract with an industrial health clinic or a medical consultant firm. It would be the responsibility of the hotel and resort chains to return all patient forms and unused medications to the LHD.

F. DISPENSING THROUGH KAISER PERMANENTE

Health Maintenance Organizations (HMOs) are a type of a managed care organization that provides health insurance in the United States. In the United States today 85% of the population has some form of health insurance (US Census Bureau, 2005). During a medical emergency most individuals turn to their health care provider or primary physician (typically associated with an HMO). Many leading HMOs conduct flu vaccine clinics for their members and therefore have some form of experience dealing with mass prophylaxis.

In the Denver Metro Area a unique relationship has developed between the LHD and Kaiser Permanente, the largest health care provider in the area. Kaiser Permanente

typically conducts a drive-thru flu clinic in the area and therefore has experience in mass prophylaxis. Kaiser Permanente also has the clinical and non clinical staff to support mass prophylaxis as well as the location and partnerships to set up a drive-thru POD. The MOU between the LHD and Kaiser Permanente states that it would be the responsibility of the LHD to provide Kaiser Permanente with prophylactic medications and forms. It would be the responsibility of Kaiser Permanente to dispense medications to their members and employees (and families of employees) only and return all unused medications and completed forms back to the LHD.

Although Kaiser Permanente typically conducts a drive thru POD using its own staff, this should not be a requirement. HMOs should be given the freedom to determine their own form of dispensing, either setting up their own traditional POD, dispensing through their own pharmacy or setting up a drive thru POD. It is generally not recommended that HMOs dispense medications through their hospitals. In fact, this should be strongly discouraged and HMOs should be required to create dispensing sites away from their hospitals. All prophylaxis plans would be required to be evaluated by the LHD prior to the event. Delivery options would need to be worked out as HMOs typically have their own logistics planning section and could therefore provide trucks and drivers. This is recommended in cases where multiple PODs would be set up by HMOs.

People are typically familiar with their HMO and turn to them for medical assistance. HMOs have large medical resources and can provide non medical staff as well. They generally have a strong bond with their members and have their medical records on file. In some cases, such as Kaiser Permanente, they are also a large employer in the area. Using HMOs to prophylax their members and their employees as well as their families can significantly reduce the burden on PODs. In the case of the Denver Metro Area, the health department anticipates having to prophylax over 450,000 people outside of PODs using Kaiser Permanente.

G. DOOR TO DOOR DISPENSING

The MOU between DHHS and USPS, in 2004, states that the USPS would suspend mail delivery during an emergency and bring medicine directly to homes, known as the postal plan (CDC, 2000). This option would only be available to areas designated

as Cities Readiness Initiative (CRI) areas based on population and geographic location (CDC, 2007). As of 2006 there are seventy two CRI areas in the United States (CRI Workshop, 2007).

The MOU holds USPS responsible for providing vehicles not immediately required for mail delivery to transport resources, report transportation disruption and damage information, provide staff for distribution and assist in the distribution of pharmaceuticals and information pamphlets as needed (USPS, 2004). The postal plan is subject to availability of resources and funding and is entirely voluntary on part of the USPS (Public Health Training Network, 2006). Postal employees would provide each household with a single bottle of doxycycline to provide the community with the first dose and prevent initial surge at PODs, giving LHDs the time to gather resources. The USPS has the capability to deliver pharmaceuticals door to door due to its nationwide presence and a vast logistical infrastructure.

On November 11, 2006, postal employees delivered empty cardboard boxes and information flyers to residents in certain Seattle neighborhoods. During the nine-hour exercise, forty one postal employees accompanied by armed police officers delivered medications to 38,000 households. Based on the average household size in Seattle, 2.05, the LHD could have initially kept 77,900 people away from PODs (15% of the population) away from PODs. These numbers could increase several fold if the number of postal employees performing the delivery is increased.

Door-to-door delivery can still be accomplished in non-CRI cities as seen in the case of Chesapeake, Virginia. This LHD accomplished the task of prophylaxing its population of 218,000 utilizing help from the school districts. Using school buses, bus drivers, escort vehicles and eight medical personnel, the LHD dispensed medication to 1,100 individuals in less than two hours. The receipt was confirmed by a phone call into an automated system that kept track of the delivery via GIS. The planners in Chesapeake Health Department now plan to prophylax their entire population using 200 school buses and with help from local Community Emergency Response Teams (CERTs) and the Medical Reserve Corps (MRC) (Linder, 2004).

Similarly, LHDs could choose to contract with UPS, FedEx or DHL to provide door-to-door delivery. All major delivery service providers have a logistic infrastructure that includes personnel, GIS tracking, and route planning software. However, security issues would need to be considered and LHDs could try to use private armed security services in case law enforcement availability is low.

H. DRIVE-THRU DISPENSING

Drive-thru prophylaxis originally gained popularity as a mechanism to deliver influenza prophylaxis to the elderly. A review of the program in the post-9/11 era determined that the program could be used to provide PPE and prophylaxis to the population while maintaining some form of isolation. The drive-thru PODs have a simple set up: patients drive to the site and while in their car, receive informed consent, have a brief history taken (to prevent contraindications) and then receive immunization while still in their car (CDC, 2007). Drive-thru dispensing seems to be a very popular alternate mode of dispensing and has been exercised and adopted by several LHDs. The Orlando LHD's plan has a throughput of 761 people per hour using thirteen medical and fifty seven non-medical staff (total of seventy) per shift (Pate, 2007). These staffing requirements are much lower than staff recommended at a POD run in the Orlando area according to the Berm staffing model. Using their drive-thru plan they anticipate prophylaxing 60% of their population.

A drive-thru POD should be located close to major roads, highways or freeways in order to prevent traffic jams. It is highly recommended that the ingress and egress points be large enough to allow multiple lanes of traffic. Similarly, the location should be large enough to accommodate multiple lanes for dispensing (Linder, 2004). The Orlando plan calls for ten lanes of dispensing to ensure a high throughput and to prevent overflow of traffic onto neighboring streets (Pate, 2007). Traffic control and security plans would have to be excellent to prevent an overflow of traffic onto adjacent freeways, highways or streets and to prevent road rage that could severely disrupt the process. It is generally not recommended that a drive-thru POD have more than three stops in order to keep the traffic flowing freely. The first stop would be for a quick triage and form completion; the

drivers would then be separated based on contraindications into a separate line and the rest would go though common lines. The final stop would be to pick up the medications.

A big advantage of drive-thru PODs is that their feasibility has been tested by the flu vaccination clinics each year. Space requirements are much more dynamic and are not bound by the strict constraints that traditional PODs are held to. In terms of security, law enforcement agencies have stated that they find it much easier to control traffic at a drive-thru POD than at a traditional POD. Another advantage to using drive-thru PODs is that the environment within the car can be climate controlled, hence protecting the population from extreme heat or cold.

There are also some disadvantages to using a drive-thru POD. POD staff are exposed to the weather conditions. Drive-thru POD would be limited to daytime operations. This is because not all park and recreation sites have outdoor lighting. LHDs must plan to remove from the line cars that break down or run out of gas. At the same time lines will still be long and it would be much more difficult for people to use facilities. There is a potentially increased risk of careless or panicked drivers, road rage, and carbon monoxide/dioxide build up.

I. DISPENSING THRU PHARMACIES

Private sector pharmacies could also be a potential partner for health departments during a public health emergency requiring mass prophylaxis. Pharmacies located at retail stores, wholesale markets, and chain pharmacies can accomplish a part of mass prophylaxis. The public is typically familiar with their local store, and the public knows and trusts them, a factor that will be critical to the success of a mass distribution effort. There is a retail pharmacy within five miles of 95% of the U.S. Population (CDC, 2002; Dufour, 2005). Every year, large retail stores with pharmacies and private pharmacy chains conduct influenza vaccination clinics at their facilities. Some of these conduct their campaign internally, whereas others contract with private community-based health service providers to organize their campaign (Singleton, 2005). Twenty-five to thirty million doses, accounting for one-third of the nation's flu vaccine, were administered by retail store/wholesale store pharmacies and private chain pharmacies (Lien, 2006).

A large number of pharmacies are located in large retail stores or strip malls, and have ample outdoor parking as well as the indoor space to accommodate a large number of people and maintain their normal operations. Pharmacies have electronic inventory systems and can receive and manage SNS inventory, a secure location to store drugs, medical staff to meet federal and state dispensing requirements and non-medical staff that can serve essential functions during the dispensing process. Above all many private retail companies would be willing to work closely with the LHDs during mass prophylaxis. In a study conducted by Dr. Onora Lien, she interviewed executives from various grocery store retail pharmacies and pharmacies located within chain wholesale clubs and they were almost undivided in their endorsement and interest in planning for and responding to a public health emergency (Lien, 2006). Representatives from these agencies noted that although they were a "For-Profit" business there was a "strong connection between assisting during an emergency and maintaining or improving their reputation within the community." (Lien, 2006)

Due to a large number of pharmacies in any area, it may be impossible or in some cases ill- advised for LHDs to obtain MOUs for all pharmacies under a brand name. It would be best to consider geospatial analysis and find optimal locations such as areas without PODs, areas with low security concerns and areas with a moderate population density. Retail store, warehouse and chain pharmacies have existing systems and relationships that enable them to deliver medicines in large quantities to the public and should therefore be considered an important partner in mass prophylaxis (CA DHS, 2003).

These alternate modes of dispensing provide several advantages over the traditional POD in terms of throughput, maximum number of people reached and staffing (both clinical and non-clinical). However, all of them require the establishment of MOUs prior to an incident. There will still be work associated with each of the options in during an incident. Therefore, LHDs should look to determine which alternatives are the "best" options to supplement the traditional POD system so they can be efficient and leverage the scarce resources optimally.

IV. EVALUATING MODES OF MASS PROPHYLAXIS

There are several alternate modes of dispensing available for mass prophylaxis beyond the use of PODs. However, currently there are no studies that analyze and compare these alternatives. Since the speed of dispensing (or total number reached where applicable), staffing requirements, and security needs for the various mode of dispensing are different, it is difficult to quantitatively estimate the advantages offered by one mode of dispensing over another.

In situations where there are multiple competing objectives, trade-offs among the objectives need to be made. For example, is saving clinical LHD staff (a scarce resource) more important than increasing the speed of dispensing? The answer to this question depends on both the decision maker's preferences and the degree to which the objectives have already been satisfied. The development of a MAVF is one approach that supports multi-criteria decisions by explicitly quantifying the trade-offs a decision maker is willing to make between attributes. Using this approach, a hierarchy of objectives is developed capturing the essence of the decision as viewed by the decision maker, the relative importance of the objectives is measured and alternatives are evaluated based on their performance on the selected objectives. The process reveals and documents decision maker's preferences. It also highlights areas where different decision makers may have points of disagreement. Finally, since the analysis is quantitative, it permits marginal and sensitivity analysis to be rapidly performed for a variety of scenarios.

A MAVF offers several advantages as it considers each alternative independently, it provides a good approximation in practice, can be easily explained, and can be understood by decision makers from non-statistical backgrounds. This process can best be viewed as a series of three steps. The first step is to develop the objectives hierarchy which clarifies the objectives of importance, how they relate to each other, and how they will be measured. The second step is to develop the individual value functions for each attribute which details how much of each attribute is desirable. In addition to transforming disparate attribute measures into a common scale, this method examines the ranges of importance and the returns to scale in terms of value over this range. The final

step is to develop the relative importance weights among the different objectives. Once all of these steps have been completed, an overall measure of value can be calculated for each alternative.

It is important to note that each of these steps reflects the subjective values of the decision maker. Depending on who is queried for input, different objectives, functions, and weights may arise. One of the strengths of this process is to force decision makers to articulate their preferences, allowing them to be discussed and analyzed. In addition, it is possible to determine how much each subjective value can change before another alternative would be chosen.

A. OBJECTIVE HIERARCHY

The goal of all alternate modes of dispensing is to prophylax a large number of people, using fewer clinical and non-clinical staff than PODs and with fewer security resources for transporting drugs to the site of dispensing and securing the site itself. All alternate modes of dispensing described in Chapter III fall into two categories: those that target the entire population within the jurisdiction of the LHD and those that target specific subsets of the entire population. This major distinguishing characteristic requires the creation of two different models to evaluate alternate modes of dispensing. The goal of each model is to determine the overall effectiveness of each alternate mode of dispensing. This will enable the LA County LHD to decide which avenues it wants to develop now so that the requisite MOUs can be set up.

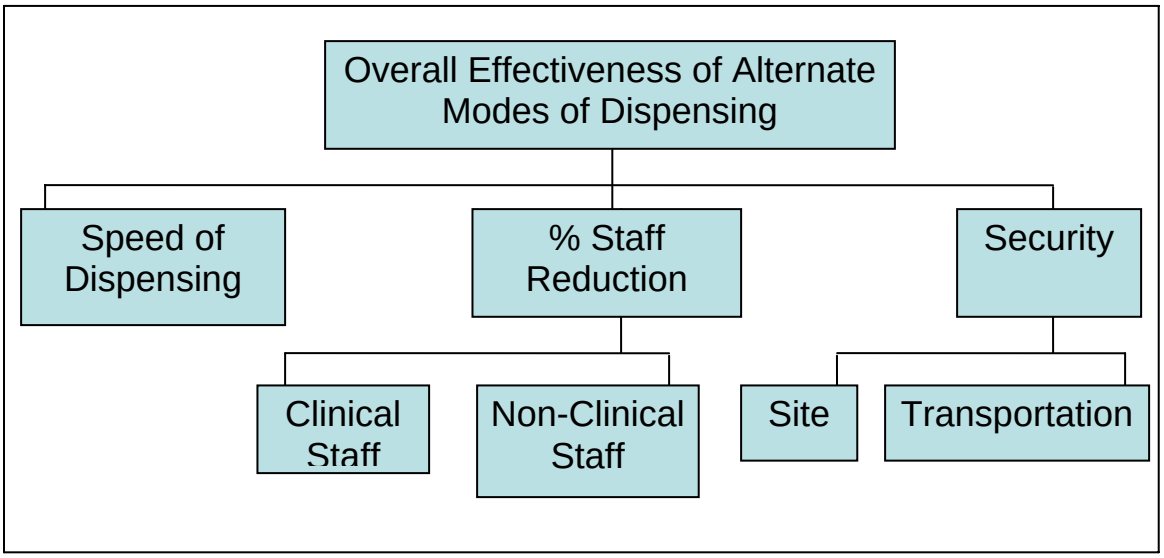
In this chapter, Model A will represent three alternate modes of dispensing that target the entire population within the LHD's jurisdiction: 1) Dispensing to the Public Through Pharmacies, 2) Drive-Thru Dispensing and 3) Door-to-Door Dispensing. Model B will represent the eight alternate modes of dispensing that target specific subsets of the general population, or 1) Pre-positioning of Medications for Civil Service Staff and their Families, 2) Pre-positioning of Medications for Hospital Patients, Staff and Staff Families, 3) Dispensing Medications at Businesses, 4) Dispensing to Sheltered-in Population, 5) Dispensing to Students at Colleges and Universities, 6) Dispensing to Residents at Major Hotel Chains, 7) Dispensing through Kaiser Permanente, and 8) Door-to-Door Dispensing. The Door-to-Door Dispensing option will appear in both models as

it can be used to prophylax the entire population within the jurisdiction of the LHD or a specific geographic area within the jurisdiction LHD.

1. Model A

In Figure 2, the hierarchy of attributes that we will use for our analysis is shown for Model A. The goal of our analysis for Model A is to determine the overall effectiveness of alternate modes of dispensing that target the entire population. This goal is based on evaluation of three independent attributes: speed of dispensing, percent staff reduction and security. Percent staff reduction is based on the evaluation of two attributes, percent reduction of clinical staff and non-clinical staff. Security is also based on the evaluation of two attributes, security requirement at the site of dispensing and security requirements to transport the drugs to the site of dispensing.

Figure 2. Hierarchy of Attributes in Model A for Analysis of Overall Effectiveness for Alternate Modes of Dispensing.



The pharmacy options are an all-or-nothing choice, which means that all pharmacies that have been agreed upon in the MOU will start dispensing medications to the general public upon activation of this plan. This is because activating pharmacies on a case-by-case basis will lead to an additional level of complexity and confusion. The

speed of dispensing for the pharmacy option is defined as the total number of people who can be prophylaxed by the pharmacy dispensing option per hour at all sites. Similarly, the door-to-door option is also an all-or-nothing approach. The speed of dispensing is similarly defined as the total number of people who can be prophylaxed by door-to-door dispensing per hour by all postal workers deployed. Finally, the speed of dispensing for the drive-thru option is the throughput at a single drive-thru POD, since they can be activated on a case-by-case basis, based on availability of staff and security. The speed of dispensing for the drive-thru dispensing options will be defined as the number of people who can be prophylaxed by the alternate mode of dispensing per hour. The speed of dispensing can be determined through exercises held by the LHDs, after action reports from other jurisdictions as well as the national TOPOFF 3 exercise and/or estimates of a work group within the LHD.

Most LHDs have two major sources for POD staffing, their government employees and volunteer staff. For example in LAC, LAC DPH could use its own employees, employees in other county departments, and non-essential employees working for city governments to staff PODs. The volunteer POD staff for LAC could come from spontaneous volunteers that arrive at local mobilization centers (MC), clinical volunteers that have registered on the Emergency System for Advanced Registration of Volunteer Healthcare Professionals (ESAR-VHP) registry and volunteers who have been registered by Volunteer Center of Los Angeles (VCLA). For each alternate mode of dispensing, the percent staff reduction is defined in comparison to the traditional POD in LA County. Only the staff for a given option that comes at the expense of a POD staff is considered in this attribute. For example, postal employees required for door-to-door dispensing do not come at the expense of POD staff as identified above and therefore would provide a staff reduction of 100% as compared to the traditional POD. This definition holds for the two sub-attribute percent clinical staff reduction and percent non-clinical staff reduction. The figures for these sub-attributes for each alternate mode of dispensing can be derived based on literature review, exercises, and/or estimates of a work group within the LHD. Baseline estimates for POD staffing to compute percent

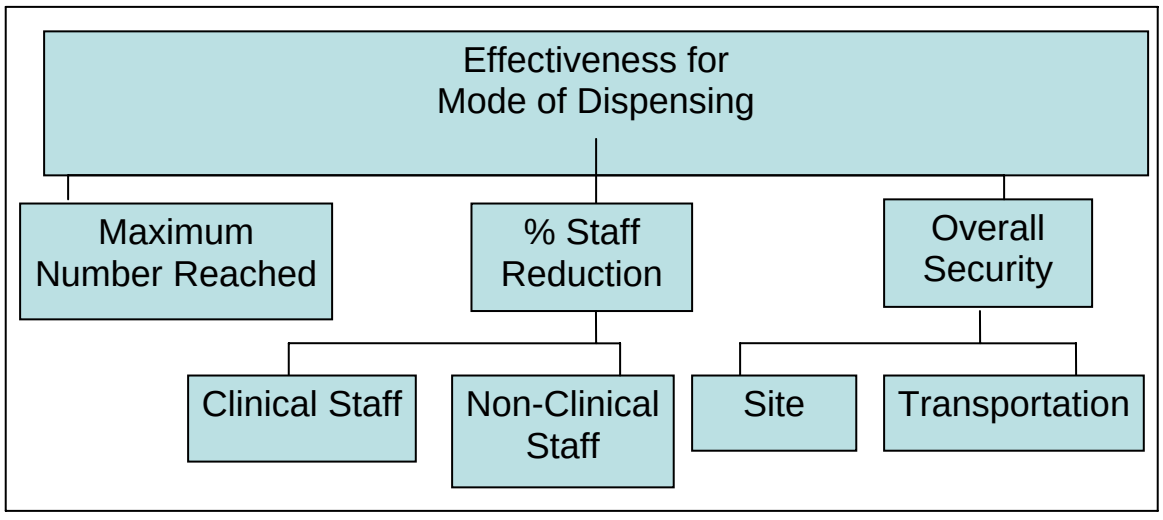
staff reduction can also be obtained from exercises and/or estimates of work groups as well as by using the BERM model for dispensing.

Overall Security is defined via its sub-attributes – transportation security and site security. Each of these is defined as a subjective assessment of the security resources that are required by each alternate mode of dispensing. The figures for each sub-attribute can be derived using a survey that is to be administered to a committee specifically dealing with security of mass prophylaxis or a similar work group. The survey should ask committee members to rate the security requirements on a scale of 1-10, with ten being the highest security requirement and one being the lowest.

2. Model B

In Figure 3, the hierarchy of attributes for Model B is shown. The goal of our analysis for Model B is to determine the overall effectiveness of alternate modes of dispensing that targets a defined subset of the entire population. This goal is based on evaluation of three independent attributes, maximum number reached, percent staff reduction and security. Percent staff reduction and security are also based on the evaluation of two sub-attributes as seen in Model A.

Figure 3. Hierarchy of Attributes in Model B for Analysis of Overall Effectiveness for Alternate Modes of Dispensing.



Unlike Model A, where speed of dispensing is an important characteristic, in Model B the maximum number reached is an important attribute since only a subset of the population is being targeted. Maximum number reached is defined as the highest number of people who can be prophylaxed using a given option. This figure is heavily dependent on how each LHD chooses to define the targeted population and requires thorough literature review to obtain estimates for the target population.

Percent staff reduction and its sub-attributes are defined as in Model A. The estimates for staff requirement for alternate mode of dispensing for a twelve-hour shift are cumulative of all sites where the alternate mode of dispensing is to be implemented. Unlike PODs that can be activated on a case-by-case basis based on availability resources, an alternate mode of dispensing can only be completely activated. The staffing estimates in Model B are heavily dependent on how an LHD defines the operation of an alternate mode of dispensing.

Security and its two sub-attributes are defined as in Model A.

B. INDIVIDUAL VALUE FUNCTION

In model A, percent staff reduction is defined as a percentage, speed of dispensing is defined as people per hour and security is measured on a scale of one to ten. In Model B, speed of dispensing is replaced by the maximum number that can be reached and the unit of measure is people. Therefore the units of all of the attributes in the two models are unique. This difference in units makes direct cross comparison of attributes (and alternatives) impossible.

An individual value function is "a relationship that transforms a measurement over a range of relevant values and converts it into a common unit of values, defined between 0 and 1 (Richter, 2007)." Once this relationship is established for each attribute, all the attributes will be measured in common units permitting them to be directly combined. In order to develop individual value functions we must first ascertain individual measurable values for each attribute for each alternate mode of dispensing. Since we have listed the units of measure, this has been done. Once these values have been ascertained it is necessary to evaluate if the scale used to evaluate efficiency of each attribute is increasing or decreasing. The scale as it relates to the speed of dispensing in

Model A and the maximum number reached in Model B is increasing, because the efficiency of the attribute depends on increasing throughput in the former and reaching more people in the latter. The scale for percent reduction in staff and overall security is decreasing in both models because the former attribute is more effective if fewer staff are required and the latter is more effective if the overall security requirement is low.

The second step to develop individual value functions requires users to set bounds for each attribute based on the decision maker's preference. These bounds are basically endpoints that define the minimum and maximum useful performance of an alternate mode of dispensing for each attribute. The lower bound (minimum useful performance) is a value below which there is no appreciable value for an attribute. In other words, all alternatives whose attribute measure is below the minimum bound are equally undesirable. Similarly, the upper bound (maximum useful performance) is a value above which there is no appreciable value for an attribute. In other words, all alternatives whose attribute measure is above the maximum bound are equally desirable.

Finally, using the formula (1)

$$v(\text{attribute}) = \frac{\text{Individual Measurable Value} - \text{Lower Bound}}{\text{Upper Bound} - \text{Lower Bound}} \qquad (1)$$

individual value functions for each attribute are determined. If the individual value function is a negative number, i.e. the individual measurable value is lower than the lower bound; the individual value function is assigned the value zero. Similarly, if the individual value function is greater than one, i.e. the individual measurable value is greater than the upper bound; the individual value function is assigned the value of one. All individual measurable values that fall between the upper and lower bound are translated to a value between zero and one. For each attribute, the function is applied to every alternative mode of dispensing.

C. RELATIVE IMPORTANCE

The final step required to calculate MAVF is setting weights for each attribute. Weights are based on the preference of the decision maker and thus represent the trade-

offs a decision maker is willing to make between attributes (Richter, 2007). Weights are typically the subjective opinion of experts, objective results of models or data analysis, or a combination of both (Richter, 2007). The weights at the highest level in the object hierarchy must add up to a value of one and the sum of weights of the sub attributes under each attribute must add up to one.

In order to analyze alternate modes of dispensing subject matter experts dealing with SNS, CRI and mass prophylaxis were administered a survey to assess the trade-off they were willing to make between the three attributes and the sub-attributes. The concept of alternate modes of dispensing is not new to the subject matter experts; however, their knowledge of MAVF is limited. The survey asks subject matter experts to divide twenty poker chips among the three top-level attributes based on the relative importance of each attribute (according to their professional opinion). They are also asked how they would divide twenty poker chips between the two sub-attributes under the attribute percent staff reduction and divide twenty poker chips for the two sub-attributes under the attribute overall security. This survey is administered twice, once for model A and once for model B. Weight values can be obtained by dividing the number of poker chips assigned to each attribute and sub-attribute by twenty (the total number of poker chips). The final weight values to be used for analysis are the average weight for each attribute and sub-attribute from the committee. The high and low values will inform the sensitivity analyses.

D. RESULTS AND SENSITIVITY ANALYSIS

Once objectives hierarchy have been established, individual value functions have been obtained for each attribute and the weights for each attribute have been determined, we can calculate the overall value of each alternate mode of dispensing. The overall effectiveness for each alternate mode of dispensing can be obtained using formula (2)

Overall Effectiveness = Sum of (value of Attribute Y * weight of Attribute Y) (2)

The product of the value of attribute Y and weight of attribute Y is the effectiveness of the attribute at a given weight for a given criteria. This analysis is

performed for both models and is graphically represented using Microsoft Excel's stacked column bar graph function. The graphical illustration shows the overall effectiveness of all alternate mode of dispensing compared to each other and shows the categorical effectiveness of each attribute across all alternate modes of dispensing. This will serve as the base case analysis.

The final weights and overall security are assessed by administering a survey to a committee comprised of subject matter experts. This committee was comprised of public health, EMS, fire department and law enforcement personnel among others. An important sensitivity analysis is to run the MAVF again using inputs of only law enforcement personnel on overall security and weights and compare it to the baseline measures. Doing so will give the LHD a better idea as to how different their perspective on the matter is from law enforcement agencies.

It is essential to examine whether changing the weights in a one-way sensitivity analysis would result in different choices. One-way sensitivity analysis determines how susceptible to change the overall effectiveness is when one parameter is varied at a time. A two-way sensitivity analysis is also performed varying two weights simultaneously. Given the constraint that the weights must sum to one, this implies that the third weight varies as well. Finally an analysis of underlying assumptions is conducted. Break point analyses are performed to understand how the changes in the assumptions of the speed of dispensing either at the POD level, the number of postal carriers, or the number of participating pharmacies influence the outcome.

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V. THE CASE OF LOS ANGELES COUNTY

A. OVERVIEW OF THE COUNTY

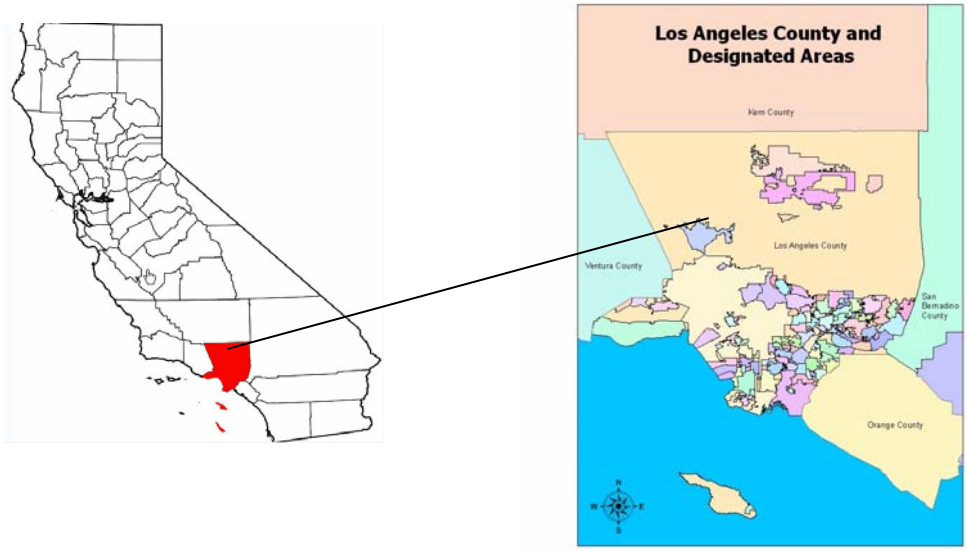
LAC is extremely large and requires additional measures to ensure that the entire county can be prophylaxed within 48 hours. Traditional PODs will not be sufficient as there is simply not enough staff to open all the PODs necessary to accommodate the population. To complicate matters, the County has several high priority targets, is a large tourist destination, neighbors a larger tourist destination, has daytime population influx, and a large sheltered in population. The models will help guide the investment in alternate modes of dispensing to best accomplish the prophylactic goals.

1. Location and Jurisdiction

The LAC located in southern California, spans across 4,752 square miles and includes flat lands, hills, mountains, valleys, lakes, rivers, marshes and islands as well as fifty miles of coastland besides the island shores (Los Angeles County Department of Public Health, 2006a). There are 2,640 square miles of unincorporated areas, which accounts for 65% of the county's total land area and houses 10% of the county's total population (Los Angeles County Unincorporated Areas, 2007). The other 35% of land is broken down into eighty eight incorporated cities that house the remaining population (Los Angeles County Unincorporated Areas, 2007). The cities vary greatly in size, with the city of Los Angeles encompassing 485 square miles followed by Palmdale at 105 square miles and, on the other hand, the smallest city of Hawaiian Gardens encompassing only .98 square miles (Los Angeles County Department of Public Health, 2006b). The LAC is divided into five Supervisoral Districts, each of which has an elected representative on the Board of Supervisors (Los Angeles County Operational Area, 2006). There are three Public Health jurisdictions in the County, one representing the entire county, one representing the City of Pasadena and one representing the City of Long Beach (Los Angeles County Department of Public Health, 2006). There are 45 local law enforcement agencies, eight Disaster Management Areas (DMAs), eight Public

Health Service Planning Areas (SPAs) (Los Angeles County Department of Public Health, 2006a). The county neighbors four other counties, three of whom have small populations. The fourth county, also the southern neighbor of the County is Orange County, the fifth most populous county in the United States, with a population of over three million. The geographic location of the County creates unique issues with delivery and since the area is so large with several freeway overpasses, tunnels and bridges, any damage to the transportation infrastructure could have a major negative impact on mass prophylaxis.

Figure 4. Los Angeles County, CA.



2. Population

California is the most populous state in the union; 29% of its population resides in the LAC and as of 2004, the county's population was larger than that of forty three states. Based on the 2005 census estimates, the LAC has a population of 9,935,4751 accompanied by a growth rate of 1.8% per year (United States Census Bureau, 2007). As of 2005, it is estimated that slightly over 8.8 million people of the total population live in the eighty eight incorporated cities and another over one million people live in the county's 112 unincorporated areas. The population density within the county is very

high: listed at 2,345 residents per square mile, but this varies greatly by city (Los Angeles County Department of Public Health, 2006b). The City of Los Angeles, for example, has the largest population in the county, a total population of 3.7 million people, followed by Long Beach with 461,000 people (United States Census Bureau, 2007). The city of Vernon, on the other hand, has a population of 95, the smallest population in the county (United States Census Bureau, 2007). The population of the county is extremely diverse due to a high rate of immigration, with people representing more than a 140 nations and speaking over 100 languages (Los Angeles County Department of Public Health, 2007b). Over four million people in the county identify themselves as Latino or Hispanic, of whom 71% are of Mexican origin (United States Census Bureau, 2007). Over one million people identify themselves as Asians, of whom 26% are of Chinese origin and 23% Korean (United States Census Bureau, 2007). About 1.8 million people (about 20% of the population) in the county are reported to have some disability (United States Census Bureau, 2007). There are 3.3 million households within the county; the average household size is 3.06 and average family size is 3.78 (United States Census Bureau, 2007). LAC has the nation's highest population living below the poverty level (45%), which, compounded by one of the nation's most expensive real estate markets, produces the nation's highest homeless population (Los Angeles County Department of Public Health, 2006b). Homelessness continues to rise in the county with estimates of 254,000 homeless during some time of the year and 82,000 homeless on any given night (Los Angeles County Department of Public Health, 2006b). According to the Bureau of Citizenship and Immigration Services, most of California's 2.5 million undocumented immigrants reside in the county (Los Angeles County Department of Public Health, 2006b). According to the Los Angeles Convention and Visitors Bureau, 5,800,000 international tourists visited Los Angeles in 2000 and during peak seasons LAC can easily have over one million tourists (Los Angeles County Department of Public Health, 2006b). The county is separated by an invisible border from its neighboring counties and up to 1.5 million residents of the neighboring counties work in LAC. Overall, the LAC

would need to plan to provide twelve million people with prophylaxis within forty eight hours of a biological attack as outlined by the CDC (Los Angeles County Department of Public Health, 2006b).

B. MODEL OF LOS ANGELES COUNTY

Recall from Chapter IV that the security rating for each option and weights for each attribute and sub-attribute were obtained using a survey. In LAC weights and security assessments both were obtained using surveys administered to a committee of stakeholders in the SNS and mass prophylaxis processes. This section will provide an overview about how this survey was implemented in LAC, as well as the results of this survey comparing the average security rating and average weights, and the rationale implemented in this paper to set the upper and lower bounds.

1. The Force Protection Committee and Security Assessment

The LAC Force Protection Committee (FPC) was established in 2002 to discuss and provide expert advice on all issues concerning the SNS and PODs. The committee is made up of representatives from local, state and federal levels of the government and represents disciplines of Public Health, EMS, Law Enforcement, Fire Department and the Military. The committee is chaired by the Disaster Services Analyst of the SNS Unit and has over fifty members. The committee was convened in 2005 to provide expert input for security analysis on PODs. The security analysis included discussions on threat analysis, risk assessment and the minimum security requirements to be established at the RSS Warehouse and the PODs during an event requiring mass prophylaxis.

This committee has performed extensive work dealing with SNS and Mass Prophylaxis Planning in LAC and the members of this committee are familiar with the security, staffing and logistic environment in LAC. For this reason, they were asked to assess the security needs for each mode of dispensing. Two types of security were considered: 1) security requirements for the transportation of supplies to the site(s) and 2) security requirements for the site(s) itself where the medication is being dispensed.

Security needs were rated on a scale of one to ten with one being low security requirements and ten being very high security requirements. Please see Appendix 1 to view the surveys.

The survey was administered to the seventeen FPC members who attended the monthly committee meeting on February 27, 2007, and emailed along with a short presentation to all other members. Of the seventeen, two members representing different law enforcement agencies declined to participate in the anonymous survey without stating any reason. None of the members who received the survey via email responded, possibly because of anonymity concerns. Of the fifteen respondents at the FPC meeting, three were law enforcement employees representing three different law enforcement agencies, eleven were public health employees representing LAC DPH and Orange County Health Care Agency (OC HCA) and one was an EMS employee.

The average overall security score for each mode of dispensing can be seen in Table 1. The security rating range for transportation and site is fairly wide for most alternate modes of dispensing. The table also shows the average security rating for transportation and site security. This rating is then compared to the average overall law enforcement and the difference is stated in the last two columns. For site security the difference between the average overall security and average law enforcement security ratings is within one unit for all modes of dispensing except for dispensing to the general public using pharmacies where the difference is 2.5 units. This shows that the site security rating between law enforcement and the entire committee is similar. When considering transportation security the average security rating and the average law enforcement security rating is greater than one unit for dispensing to the general public using pharmacies (difference of 2.5) and Pre-positioning of Medications for Hospital Patients, Staff and Families of the Staff (difference of 1.8).

The average security rating for two of the three options considered in Model A (dispensing to the general public) was lower than that of the traditional POD under transportation security. All three options had a lower security requirement than a traditional POD when site security was compared among the options. However, according to the average law enforcement rating, dispensing to the general population

using pharmacies was rated lowest compared to the traditional POD for site and transportation security. Six of the seven alternate modes of dispensing under Model B had an average security rating lower than that of the traditional POD for site and transportation security. The only option that had a higher security rating was the Door-to-Door dispensing option.

Table 1. Security Rating Averages and Ranges for Transportation and Site Security.

	DISPENSING OPTIONS	**TRANSPORTATION SECURITY RATING**				**SITE SECURITY RATING**			
		Security Rating Score	**Average Security Rating**	**Average Law Enforcement Security Rating**	**Difference**	**Security Rating Score**	**Average Security Rating**	**Average Law Enforcement Security Rating**	**Difference**
1	Traditional POD (LAC Model)	2 TO 10	6.4	6.3	0.1	5 TO 9	7.6	8.0	-0.4
2	Drive Thru Dispensing	2 TO 10	6.5	7.3	-0.8	5 TO 9	7.4	7.3	0.1
3	Door to Door Dispensing	2 TO 9	6.6	5.7	0.9	6 TO 10	7.5	8.0	-0.5
4	Dispensing to the General Public Using Pharmacies	4 TO 8	4.8	7.3	-2.5	4 TO 10	5.8	8.3	-2.5
5	Pre-positioning of Medications for Government Employees and their Families	1 TO 10	4.1	5.0	-0.9	2 TO 10	4.5	4.7	-0.2
6	Pre-positioning of Medications for Hospital Patients, Staff and Families of the Staff	2 TO 10	3.8	2.0	1.8	2 TO 10	4.4	3.7	0.7
7	Dispensing of Medications at Private Businesses	2 TO 9	5.3	6.3	-1.0	3 TO 9	5.1	5.3	-0.2
8	Dispensing of Medications to Sheltered in	3 TO 9	5.3	5.0	0.3	1 TO 8	3.8	3.3	0.5

	Populations								
9	Dispensing of Medications to Students at Colleges and Universities	3 TO 7	5.3	6.0	-0.7	2 TO 9	4.5	4.3	0.2
10	Dispensing of Medications to Hotel Chains for their Residents, Employees and Families of Employees	3 TO 8	5.2	5.3	-0.1	3 TO 9	6.0	5.7	0.3
11	Dispensing of Medications to Members of Kaiser Permanente	2 TO 10	4.9	5.0	-0.1	2 TO 10	4.2	4.3	-0.1

2. Developing Individual Value Functions

Recall from Chapter IV that in this analysis linear approximation has been used and therefore there is only a need to determine the minimum and maximum values for each criterion. All values that are equal to or above the maximum value are evaluated as one, whereas all values that are equal to or below the minimum value are evaluated as zero. All values in between the minimum and the maximum are interpolated via a straight line.

3. Setting Maximum and Minimum for Model A

Speed is critical in dispensing and therefore an option that provides a speed slower than that of a traditional POD does not provide any added benefit and therefore the lower bound would be set at the speed of prophylaxis as defined at a traditional POD. The upper bound would be set at a point ten times faster than the traditional POD.

During an event, it may be more difficult to arrange for clinical staff than non-clinical staff. Therefore the maximum and minimum bounds for the two staffing subcategories may not be the same. Since there is a large shortage of clinical staff every

individual who can be spared is critical. It will always be best to have an option that reduces clinical staffing by 100%, making this the upper bound. Any option that requires more or the same amount of clinical staff as required by the traditional POD does not provide any added benefit and would therefore serve as the lower bound. Considering the government of LAC is the largest employer in the county it may be easier to obtain non-clinical staff. While a reduction of non-clinical staff would be considered advantageous, the incremental benefit of additional staff reductions is decreasing. Any option that provides greater than a 75% non-clinical staff reduction may not provide an added benefit to the staffing category. Therefore, this becomes the upper bound. On the other hand, any option that does not reduce the non-clinical staffing by at least 25% does not have much impact on the staffing. Therefore, 25% can be considered the lower bound.

Since security is a strong component of an efficient mass prophylaxis strategy, and since security will be a critical resource, the lower the security requirement the better the option. Any option that requires more security than the POD option does not provided any added benefit. Therefore, we use the POD security average as obtained from the FPC as the lower bound. The upper bound would be the lowest possible security rating on the rating scale, i.e. a one. All minima and maxima for Model A are summarized in Table 2.

Table 2. Upper and Lower Bounds for Model A.

	MINIMUM	**MAXIMUM**
Speed of Dispensing	Speed at POD	10 X Speed at POD
% Clinical Staff Reduction	0%	100%
% Support Staff Reduction	25%	75%
Transportation Security	6.4	1
Site Security	7.6	1

4. Setting Maximum and Minimum for Model B

Considering that LAC must plan to provide prophylaxis to twelve million people within forty eight hours, planners must consider the amount of stress reduced on PODs as a measure to set the maximum and minimum bounds. The lower bound would be set at the mark equal to the number of people who can be reached by a POD in forty eight hours. The upper bound would be set at the mark five times faster than that.

The staffing and security bounds would be the same as the bounds in Model A. All minima and maxima for Model B are summarized in Table 3.

Table 3. Upper and Lower Bounds for Model B.

	MINIMUM	**MAXIMUM**
Maximum Number Reached	The Number Prophylaxed by a POD in 48 hours	5 X The Number Prophylaxed by a POD in 48 hours
% Clinical Staff Reduction	0%	100%
% Support Staff Reduction	25%	75%
Transportation Security Rating	6.4	1
Site Security Rating	7.6	1

5. Setting Relative Importance

It is important to assess the trade-offs that stakeholders in LAC are willing to make between attributes. In our case the LAC FPC members were asked to complete a survey to assess their priorities based on their professional opinion. Committee members were asked to divide twenty poker chips among the three attributes (See Appendix 2) and twenty poker chips among the sub-attributes under each attribute based on their assessment of relative importance. To obtain the weights for the analysis, the number of poker chips they attributed to each attribute and sub-attribute were divided by twenty.

The range of weights for both models was wide. The sub-attributes' percent of clinical staff reduction received a much higher weight as compared to percent of non-clinical staff reduction for both models. The sub-attribute site security rating received a much higher rating as compared to the transportation security rating for both models. The relative importance assessment of attributes between law enforcement and the entire community differed by greater than .02 units on most attributes and sub-attributes. This difference was most significant for the security rating. The relative importance weights for each attribute and sub-attribute are shown in Table 4 below.

Table 4. Average and Range of Weights.

	Range	**Average Weight**	**Average Law Enforcement Weight**	**Difference**
MODEL A				
Speed of Dispensing	.2 TO .5	0.36	0.31	0.05
% Staff Reduction	.2 TO .4	0.29	0.28	0.01
% Clinical Staff Reduction	.5 TO .7	0.59	0.60	-0.01
% Non-Clinical Staff Reduction	.3 TO .5	0.41	0.40	0.01
Security Rating	.2 TO .5	0.35	0.40	-0.05
Site Security Rating	.4 TO .7	0.61	0.55	0.06
Transportation Security Rating	.3 TO .6	0.39	0.45	-0.06
MODEL B				
Maximum Number of People Reached	.3 TO .65	0.40	0.38	0.02
% Staff Reduction	.2 TO .6	0.31	0.25	0.06
% Clinical Staff Reduction	.55 TO .7	0.61	0.65	-0.04
% Non-Clinical Staff Reduction	.3 TO .45	0.39	0.35	0.04
Security Rating	.1 TO .5	0.29	0.37	-0.08
Site Security Rating	.4 TO .65	0.57	0.57	0.00
Transportation Security Rating	.35 TO.6	0.43	0.43	0.00

C. ASSESSING ATTRIBUTES FOR TRADITIONAL PODS IN LOS ANGELES COUNTY

In LAC the Emergency Preparedness and Response Program was tasked to plan for an event requiring mass prophylaxis. During Operation Chimera Exercise Series in 2005, a full-scale POD exercise was conducted in Glendale, California on February 2. Based on the After Action Report, the rate of dispensing (the speed) was 1,500 people per hour at that site. Based on the streamlined POD staffing model obtained from the Mass Prophylaxis Unit within the program, they estimate that a throughput of 1,500 per hour can be obtained using only seventy two staff members per shift. According to the 2005 Census Bureau estimates, the average family size in the county is 3.06, therefore the county can potentially prophylax 4,590 people per hour assuming heads of household are allowed to take medications back for household members. Based on cross comparison of the throughput and staffing information obtained from the LAC DPH Emergency Preparedness and Response Program with the BERM Model of Dispensing, the staffing numbers were significantly different between the two. Based on a population of twelve million, a throughput of 1,500 people per hour, using two twelve-hour shifts per day for a forty-eight-hour campaign, the BERM model suggests ninety eight staff per clinic per shift. This difference can be attributed to the different flow models being considered. The LAC POD flow model is much more streamlined and does not require briefing.

The goal of all alternate mode of dispensing is to reduce the pressure on PODs without dipping into critical resources like staffing and security. The POD staffing requirements will serve as a baseline for percent staff reduction attribute. This is because any option that has a lower staffing requirement, as compared to the POD, will be preferred to an option that has a higher staffing requirement. Of the seventy two staff members, twelve would be clinical staff and sixty would be non-clinical staff. Since the traditional POD as used in LAC serves as the baseline for our mass prophylaxis model all calculations will be with respect to these numbers. See Table 5.

Table 5. Traditional POD - Base of Comparison for Alternate Modes of Dispensing.

	DISPENSING OPTIONS	SPEED	STAFF REQUIREMENTS	
			CLINICAL	NON-CLINICAL
1	Traditional POD (LAC Model)	4,590	12	60

D. ASSESSING ALTERNATE MODES OF DISPENSING IN MODEL A

Recall that in Model A, the goal is to determine which alternate mode of dispensing to initiate after the original corps of PODs has been opened. As demonstrated in Chapter IV, Model A has three alternate modes of prophylaxis: door-to-door dispensing, drive-thru dispensing and dispensing through pharmacies.

The decision to open a Drive-Thru POD is based on availability of resources. That is, it will be opened only when resource needs (staffing and security) are met and can therefore be opened one by one. However, dispensing through pharmacies and the door-to-door dispensing option are all-or-nothing approaches. The speed of dispensing for the former option will be defined as the number of people that can be prophylaxed by alternate mode of dispensing per hour and for the latter option as the sum of number of people who can be prophylaxed by the alternate mode of dispensing per hour at all sites or all postal carriers. For some of the alternatives, LAC has conducted exercises and therefore has detailed information on the staffing numbers and through put for the given mode. Some alternatives have not yet been tested in LA County. For these alternatives, the staffing and throughput numbers from the jurisdiction(s) which originally implemented them have been used. The overall summary of the values for each mode of dispensing in Model A can be found in Table 6. The following sections detail how the numbers were obtained for each alternative.

Table 6. Values of Attributes for All Alternate Modes of Dispensing in Model A.

	DISPENSING OPTIONS	SPEED	% STAFF REDUCTION	
			CLINICAL	NON-CLINICAL
1	Drive-Thru Dispensing	2,328	0%	4%
2	Door-to-Door Dispensing	71,388	100%	100%
3	Dispensing to the General Public Through Pharmacies	32,555	100%	100%

1. Examining Drive-Thru Dispensing

Drive-Thru PODs have been utilized in the private sector during seasonal flu clinics and by the public sector during bioterrorism preparedness exercises such as in Hawaii in 2003. Orange County, Florida, plans to prophylax 60% of its population using this option. The plan calls for the use of ten Drive-Thru PODs with ten dispensing lanes each. The expected throughput for this model is 761 heads of household, or 2,328 doses distributed per hour per site (based on the average family size of 3.06). The plan requires a staffing of twelve medical personnel and fifty eight non-medical personnel for a total staff of seventy people per shift per Drive-Thru POD. Since drive-thru oral dispensing has not been tested in LAC, the Orange County, Florida model will be applied in the analysis and therefore we have a staff reduction of 4% for non-clinical staff and 0% for clinical staff.

2. Examining Door-to-Door Dispensing

The Door-to-Door Dispensing option has been a subject of heated debate in LAC since 2005. It is difficult to assess the speed of dispensing for such an option because it has never been tested in LAC. This option was tested in Seattle in 2007; however, these

numbers cannot be directly applied to LAC due to inherent differences in population, traffic patterns, and the total number of postal carriers available. Based on the assessment provided by local USPS representatives to the LAC FPC there are 7,500 postal routes in LAC and 3,750 postal carriers, working two routes each, could potentially deliver initial doses of medications to 70% of LAC's population in less than twenty four hours.

According to the United States Census Bureau there are 9,935,457 residents in LAC living in 3,339,763 households. Based on the assumptions above:

3,339,763 households * 70% of LAC's population that can be reached = 2,227,834 households that can be reached by 7,500 routes. This translates to 298 households per route.

Since each postal employee will deliver two routes within twenty four hours we can reach 596 households in a twenty-four-hour period by each postal carrier. The average household size in the LAC is 3.06 individuals, therefore using the postal option we can provide initial doses to 1824 people per twenty-four-hour period per worker. Therefore we can provide initial doses to seventy six people per hour per worker.

According to the CDC, during bioterrorism events employers can expect high rates of absenteeism. Local law enforcement in LAC has therefore not guaranteed one-on-one protection for the 3,750 postal carriers to carry out this option; since it is voluntary on the part of the postal carriers and requires one-on-one security, the number of postal workers who would actually be available is probably relatively low. We will assume 25% of the required workforce will be available as the worst-case scenario, based on security and absenteeism considerations and further test this assumption in our sensitivity analysis.

Using a workforce of 25% of the postal carriers required (938 postal carriers) LAC can expect a speed of dispensing of 71,388 people per hour. As the dispensing process would be carried out entirely by postal carriers, LAC can expect a 100% reduction in staffing (both clinical and non-clinical) for this option.

3. Examining Dispensing Thru Pharmacies

Developing throughput for dispensing to the general public through pharmacies is extremely difficult because numbers for such an operation are not available through exercises either in LAC or elsewhere in the United States. Therefore the throughput estimates for this analysis are mathematically derived using POD throughput data. During a bioterrorism event people will still need their daily medications; hence, unlike the postal option where all general mail delivery would be suspended, pharmacies must maintain their daily operations. Therefore this analysis assumes that only a single pharmacist at the pharmacies will be available to dispense prophylaxis full-time, and the rest will carry out normal functions. Since the ratio of clinical to non-clinical staff is 1:5 at a traditional POD, this option will require five support staff in addition to the pharmacist.

LAC plans to process 1,500 people per hour per POD using twelve clinical staff and sixty non-clinical staff. Since only clinical staff will be performing the dispensing operation and assuming that the throughput to clinical staff ratios are equal between PODs and Pharmacy PODs, consider the following ratio:

$$\frac{\text{Throughput at Pharmacy}}{\text{Number of Clinical Staff}} = \frac{\text{Throughput at POD}}{\text{Number of Clinical Staff}}$$

Based on the ratio above we can estimate the throughput at the pharmacy to be 125 people per hour. Since the average household size in the county is 3.06, using this option the county could prophylax 383 people per hour at each site. If MOUs with Sav-on, Rite Aid or Walgreens are signed and LAC is allocated only 5% of the 1,700 pharmacies within its borders it can still prophylax 32,555 people per hour.

E. ASSESSING ALTERNATE MODES OF DISPENSING IN MODEL B

Recall that in Model B, the goal is to determine the overall effectiveness of alternate modes of dispensing that targets a defined subset of the entire population. Chapter IV Model B has eight different modes of prophylaxis: Pre-positioning of

Medications for all Government Employees and their Families, Pre-positioning of Medications for all Hospital Patients, Staff and their Families, Dispensing of Medications at Private Businesses, Dispensing of Medications to SIPs, Dispensing of Medications to Students at Colleges and Universities, Dispensing of Medications to Hotel Chains for their Guests, Employees and Families of Employees, Dispensing of Medications to Members of Kaiser Permanente and Door-to-Door Dispensing. No exercises have actually taken place in the county itself to test any of the modes of dispensing listed above. The estimates for the maximum number reached using each alternate mode of dispensing is an estimate of how many people actually fall into the subgroup being targeted. The estimates for percent staff reduction are based on how each option would be applied in LAC, and the overall security assessment for each mode is once again based on the survey administered to the committee. The overall summary of the values for each mode of dispensing in Model B can be found in Table 7. The following sections detail how the numbers were obtained for each alternative.

Table 7. Values of Attributes for All Alternate Modes of Dispensing in Model B

	DISPENSING OPTIONS	**Maximum # Reached**	**% STAFF REDUCTION**	
			CLINICAL	**NON-CLINICAL**
1	Pre-positioning of Medications for Government Employees and their Families	1,934,982	100%	100%
2	Pre-positioning of Medications for Hospital Patients, Staff and Families of Staff	405,497	100%	100%
3	Dispensing of Medications at Private Businesses	1,402,565	91.6%	68.3%
4	Dispensing of Medications to Sheltered in Populations	463,321	66.6%	-5.6%
5	Dispensing of Medications to Students at Colleges and Universities	653,243	83.3%	36.6%
6	Dispensing of Medications to Hotel Chains for their Guests, Employees and Families of Employees	213,212	91.6%	68.3%
7	Dispensing of Medications to Members of Kaiser Permanente	1,200,000	100%	100%
8	Door-to-Door Dispensing	1,095,592	100%	100%

1. Pre-positioning of Medication for all Government Employees and Their Families

According to the California Employment Development Department, Government agencies provide 14% of all employment in LAC. According to the LA Almanac's assessment of the California Employment Development Department there will be 511,900 employees by 2008 working for local governments within LAC (LA Almanac, 2007a).

Taking into account the average family size of 3.78, using this pre-positioning option the LAC DPH could potentially prophylax 1,934,982 people. This can be accomplished without using any of its staffing assets (as defined in Chapter IV) during an emergency.

2. Pre-positioning of Medication for all Hospital Patients, Hospital Staff and Their Families

According to the Office of Statewide Health Planning and Development at the California Health & Human Services Agency there are a total of 126 hospitals in LAC and the total bed capacity in the county is 31,132 beds with an occupancy rate of 51.9% (LA Almanac, 2006; Berliner, 2002). Based on the 2003 assessment of Hospitals in LAC by the California Employment Development Department there are 103,000 employees working in the hospital system in LAC (LA Almanac, 2006). Taking into account the average family size of 3.78, using this pre-positioning option the LAC DPH could potentially prophylax 405,497 people. This can be accomplished without using any of its staffing assets during an emergency.

3. Dispensing of Medications at Private Businesses

LAC has several large employers within its borders. However, during an emergency it may not be feasible to provide medication to all of them. For the purposes of this analysis we will consider the twenty five largest employers and other employers that deal with critical infrastructure. Based on the research performed by LA Almanac and the Los Angeles Business Journal, the twenty five largest employers employ 280,219 people (LA Almanac, 2007c). LAC should also take into account critical infrastructure

industries because it is essential that transportation facilities, telecommunication, radio and television, waste management and water as well as electric utilities are running optimally. According to the 2003 data available through the California Employment Development Department there are 24,000 employees working in air transportation, 5,800 in commuter rail transportation, and 11,300 in ground transit in LAC. There are 12,300 employees in agencies dealing with radio and television and 28,300 employees in agencies dealing with telecommunication. There are 8,100 employees working in companies dealing with waste management (LA Almanac, 2007a). There are six agencies that provide electricity to communities within LAC however, only a single one, Southern California Edison, is privately run and is one of the twenty five largest employers in the county. Four are city-run and one is run by the county. There are an additional 1,030 employees working in private companies that supply communities with water. Therefore using private sector resources we can prophylax 1,402,565 people (total employees * average family size). Regarding staffing we will assume that the county will require all businesses to provide their own staff. However, the county must still operate a distribution site where businesses can send representatives to pick up their medications. The site is basically a warehouse distribution operation and would probably require one clinical staff to oversee operations. Since this is simply a distribution process and there is no real dispensing taking place, LHDs may require only a single clinical staff to oversee the process. This distribution operation is similar to the Receipt, Store and Stage Warehouse (RSS Warehouse) operation outlined by the CDC to distribute and deliver medications to PODs. LAC estimates that a single team required for distribution at the RSS Warehouse will consist of twenty members. Using these numbers the percent staff reduction values for LAC are 68.3% reduction in non-clinical staff and 91.6% staff reduction in clinical staff.

4. Dispensing of Medications to Sheltered in Populations

LAC has 402 nursing homes, with a cumulative total of 38,970 beds. Of these, 370 are considered skilled nursing facilities (The Urban County CDBG Program, 2001). The total residential population at these facilities is 37,600, according to the LAC Housing and Community Development Consolidated Plan (The Urban County CDBG

Program, 2001). The plan also states that there are 43,700 people living in 1,280 residential care facilities. The largest sheltered in population in the LAC are the 58,975 inmates confined to eight penitentiaries. If residents and inmates are being prophylaxed it will also be critical to prophylax all staff at these facilities. Based on the 2003 estimates of the California Employment Development Department there were 64,400 staff at Residential Care and Nursing Facilities (LA Almanac, 2007a). Unfortunately no concrete numbers were available for the total number of employees responsible for inmate welfare specific to LAC. However, according to the United States Department of Justice there were 2.8 inmates per employee in correctional facilities nationwide. Using this ratio we will assume that there are 21,062 employees in LAC responsible for inmate welfare. Since we will also be dispensing medication for family members of employees at all facilities we can estimate that using this option we may therefore be able to dispense medications to 463,321 people. There are over 1,700 of these facilities located over a large area throughout LAC; it is strongly recommended that the county have one SIP site that serves two SPAs. SIPs sites are a simple warehouse operation similar to the distribution centers being used for Dispensing Medications at Private Businesses and would therefore have similar staffing requirements. However, there are eight SPAs in LAC; therefore the staffing requirement would be seventy six non-clinical staff and four clinical staff. The percent staff reduction for non-clinical staff is therefore -5.6% and for clinical staff is 66.6%.

5. Dispensing of Medications to Students at Colleges and Universities

According to the LA Almanac there were 481,631 students enrolled in sixty one colleges and universities in LAC (LA Almanac, 2007d,e). According to the California Employment Development Department report based on 2003 data there are 45,400 employees working at these institutions. Assuming that all colleges and universities have a health center or has pre-established contacts with a community clinic and since we plan to provide medications to the family of staff members we can easily estimate that we can prophylax 653,243 people using this option. Since there are only sixty one colleges and universities, LAC DPH would distribute medications to the universities and colleges with the largest populations first. Once again, a distribution center would be required to

distribute medications to the sixty one colleges and universities; LAC DPH should plan to have at least two distribution centers (similar to other options). The percent staff reduction for this option would be 36.6% for non-clinical staff and 83.3% for clinical staff.

6. Dispensing of Medications to Hotel Chains for Their Residents, Employees and Employee Families

According to the California Department of Tourism there are 627 Hotels in LAC with an average occupancy rate of 78.5%. There are 93,000 rooms in the LAC and there are approximately 24.8 million overnight visitors to LAC every year (The Convention and Visitors Bureau, 2007). This translates to roughly 73,005 individuals in hotels at any given time using a conservative estimate of one person to a room. According to the California Employment Development Department there are 37,092 employees working in the hotel industry (LA Almanac, 2007a). Based on this (and an average family size of each employee at 3.78) we can estimate to prophylax 213,212 individuals. Since the highest concentration of hotels is in downtown Los Angeles the warehouse distribution operation to supply hotels with medication should be located close to that area. The warehouse distribution operation would require twenty staff (nineteen clinical and one non-clinical). The percent staff reduction for this option would therefore be 68.3% for non-clinical staff and 91.6% for clinical staff.

7. Dispensing of Medications to Members of Kaiser Permanente

Kaiser Permanente is the largest health care provider in LAC with 1.2 million members in the county according to the Los Angeles Business Journal (Los Angeles Business Journal, 1996). A contract with Kaiser to prophylax its own staff, their families and all their members would significantly reduce the strain on traditional PODs. Since almost all Kaiser Permanente employees and their family members are also clients of Kaiser Permanente we will conservatively use 1.2 million as the maximum number reached in the LAC. A single large delivery would be made to a central location designated by Kaiser Permanente and it would be the responsibility of Kaiser Permanente to distribute the drugs to all facilities they plan to operate. Since the RSS Warehouse is

active during POD operations, staff required for Warehouse functions of distribution do not count as staff specifically required for mass prophylaxis. Therefore the percent staff reduction for this option will be 100% for both clinical and non-clinical staff.

8. Door-to-Door Dispensing

There are 1,095,592 residents of LAC living in unincorporated county areas (Los Angeles County, 2007). While it is generally understood that the responsibility to provide basic social services to these individuals lies with the LAC, there are no specific plans and procedures specific to this population in terms of disaster and bioterrorism preparedness. If the Postal Option is used for such a targeted population we can deliver medications to over one million people without using any LHD staff assets. This would be especially important because currently there are no traditional PODs in unincorporated areas in LAC and the absence of PODs here would increase the pressure on PODs located in neighboring cities.

The values of all attributes, weights and bounds will be combined in Microsoft Excel and analyzed. The following chapter discusses the calculations in detail as well as the specific results.

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VI. RESULTS

This chapter provides an overview of the results that were obtained using the decision analytic model. For both models we performed our baseline analysis using the average weights obtained from the LAC FPC. Several sensitivity analyses were conducted to test the robustness of the results. The first sensitivity analysis examines the impact of using the weights and security ratings for each alternative from the surveys filled out by only those members who represented a law enforcement agency. Next, we examined whether changing the weights in a one-way sensitivity analysis would result in different choices. A two-way sensitivity analysis of all top weights and a breakpoint analysis for assumptions were also performed.

A. MODEL A

Model A aims to serve the entire population of the county and does not specifically cater to any subset of the population. The three alternate modes of dispensing that fall in this category are Drive-Thru Dispensing (referred to as the Drive-Thru Option), Door-to-Door Dispensing and Dispensing to the General Public through Pharmacies (referred to as the Pharmacy Option).

1. Baseline Analysis Based on Weights and Security Assessment of Law Enforcement Only

According to our analysis using the average response, none of the alternate modes of dispensing in Model A met our ideal because no single mode performed well across all three attributes. The most optimal alternate mode of dispensing was Door-to-Door Option, followed closely by the Pharmacy Option. The worst option in Model A was the Drive-Thru Option.

Based on categorical analysis the Door-to-Door Option and the Pharmacy Option provided optimal reduction in clinical and non-clinical staffing as compared to a traditional POD. The Door-to-Door Option provides a higher speed of dispensing as compared to the Pharmacy Option and both options have a higher speed of dispensing as compared to a traditional POD. The Door-to-Door Option provides no added benefit in

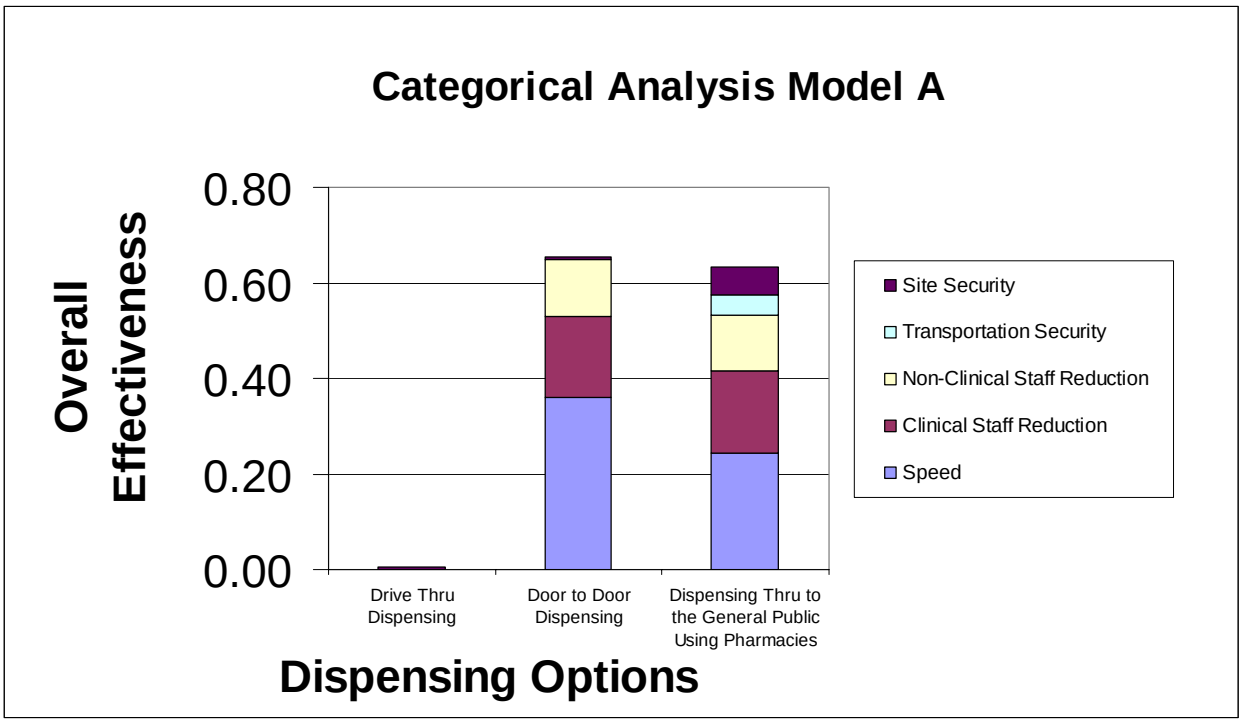
terms of security, neither transportation nor site as compared to a traditional POD. On the other hand, the Pharmacy Option provides added benefit in terms of security as compared to a traditional POD. See Table 8 and Figure 5.

The Drive-Thru Option provided no significant improvement in speed, staff reduction or transportation security over the traditional POD or any other alternate mode of dispensing in Model A, making it the least favorable option.

Table 8. Summary of Baseline Analysis for Model A.

Alternate Modes of Dispensing	**Speed**	**Percent Staff Reduction**		**Security**		**Overall Effectiveness**
		% Clinical Staff Reduction	*% Non-Clinical Staff Reduction*	*Transportation Security*	*Site Security*	
Drive-Thru Dispensing	0.00	0.00	0.00	0.00	0.01	**0.01**
Door-to-Door Dispensing	0.36	0.17	0.12	0.00	0.00	**0.65**
Pharmacy Option	0.24	0.17	0.12	0.04	0.06	**0.63**

Figure 5. Categorical Baseline Analysis of Model A.



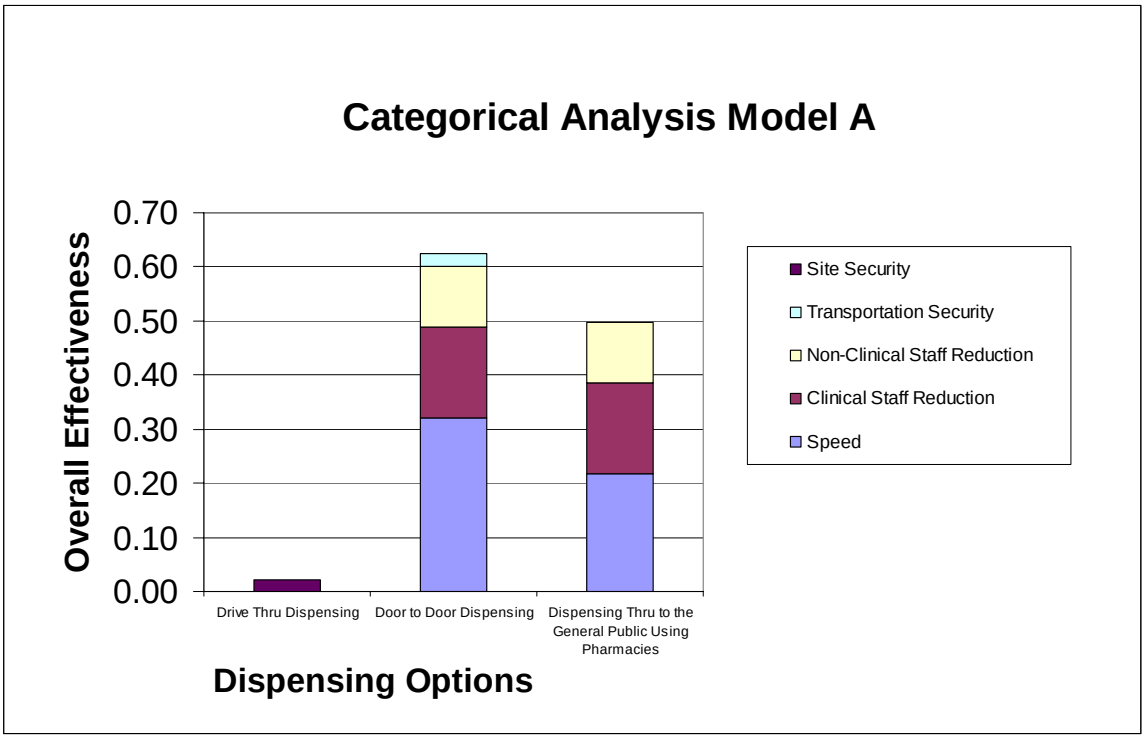
2. Based on Weights and Security Assessment of Law Enforcement Only

Using the weights and the security assessment provided by members of the FSP who were in Law Enforcement, the Door-to-Door Option was still the most favorable option with an overall effectiveness of .62. This is followed by the Pharmacy Option with an overall effectiveness of .50. The overall effectiveness for both these options is lower than our baseline measure. However, the drop in overall effectiveness for the Pharmacy Option is significant. The major change is that the Pharmacy Option no longer provides any added benefit in terms of site security as compared to the traditional POD. However, law enforcement officials felt that the Door-to-Door Option provides slightly better transportation security as compared to the LAC POD but Dispensing through Pharmacies did not. The Drive-Thru Option has an overall effectiveness that is much lower at .02 but is slightly higher than our baseline. See Figure 6 and Table 9 for further details. The remaining decline in effectiveness was due to the change in weights, as law enforcement officials gave a slightly higher weight to security at .4.

Table 9. Summary of Law Enforcement Analysis for Model A.

Alternate Modes of Dispensing	**Speed**	**Percent Staff Reduction**		**Security**		**Overall Effectiveness**
		% Clinical Staff Reduction	*% Non-Clinical Staff Reduction*	*Transportation Security*	*Site Security*	
Drive-Thru Dispensing	0.00	0.00	0.00	0.00	0.02	**0.02**
Door-to-Door Dispensing	0.32	0.17	0.11	0.02	0.00	**0.62**
Pharmacy Option	0.22	0.17	0.11	0.00	0.00	**0.50**

Figure 6. Categorical Law Enforcement Analysis for Model A.



3. One-Way Sensitivity Analysis of Weights

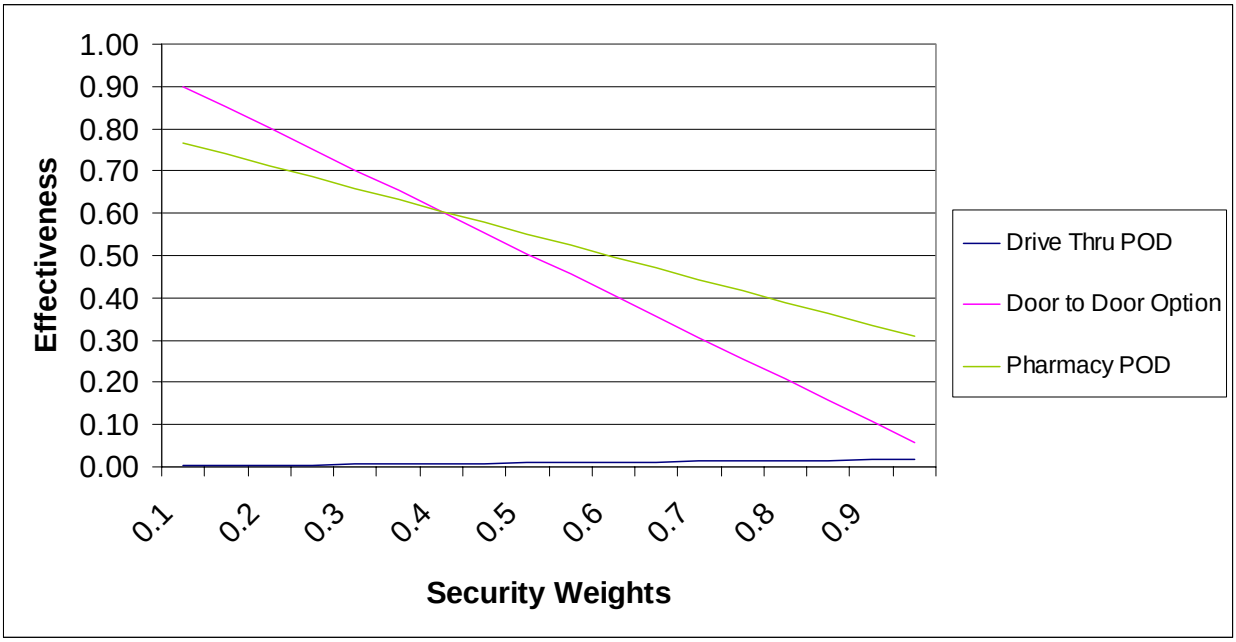
A one-way sensitivity analysis of weights is performed to understand how the overall effectiveness of all alternate modes of dispensing changes when one weight of any attribute is changed. Since all weights must add up to 1, the two other attributes must retain their original proportions as set in the baseline analysis. We will first assess the effects of the change in the weights for security, followed by speed of dispensing and finally the percent staff reduction.

a. Based on Security Weights

In order to assess the sensitivity of the results to a change in the weight of security we gradually increased the weight of security by increments of .05, ranging from .1 to .95. The ratio between the weights of percent staff reduction and speed of dispensing were set equal to the ratio between the two at baseline such that all weights add up to 1.

As seen in Figure 7, when the weight of security increases, the overall effectiveness of the Door-to-Door dispensing option and the Pharmacy Option decreases. The decrease in overall effectiveness is more pronounced in the Door-to-Door dispensing option. The increase in security has a negligible positive effect on the Drive-Thru option. The break point between the Door-to-Door dispensing and Pharmacy Option is at approximately .42. Since the weight dedicated to security by the FPC in LAC is at .35 for Model A and ranges between .2 and .5 it is difficult to recommend one option between these two alternate modes of dispensing in Model A. Only if the range of weights no longer includes the breakpoint can a clear recommendation be made. If the lower bound of the weights rises above .42 then the Pharmacy Option is clearly the better option.

Figure 7. One-way Sensitivity Analysis of Security Weights for Model A.

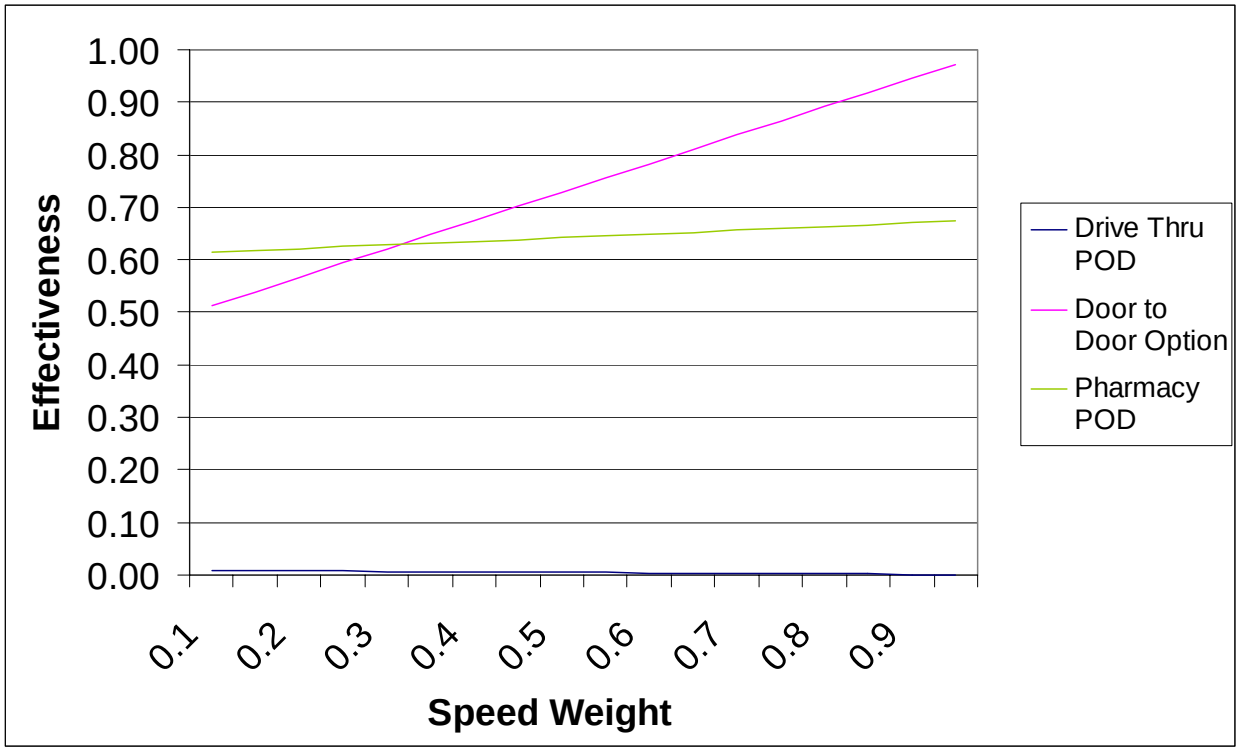


b. Based on Speed of Dispensing Weights

As in the one way analysis for security weights, the weights for the speed of dispensing will be increased in increments of .05 between .1 and .95. The ratio between the weights of percent staff reduction and security were set equal to the ratio between the two at baseline, such that all weights add up to 1.

As seen in Figure 8, when the weight on the speed of dispensing increases the effectiveness of the Pharmacy Option and the Door-to-Door dispensing option increases. The change in the Drive-Thru POD option is negligible. The breakpoint between the options is approximately at .35. Since the weight set by the LAC FPC for the speed of dispensing is at .36 and ranges between .2 and .5 it is difficult to recommend one option over the other with great confidence at the weight set by the FPC. However, as the weight on the speed of dispensing rises then the Door-to-Door dispensing option is the recommended option.

Figure 8. One-Way Sensitivity Analysis of Speed Weights for Model A.



c. Based on Percent Staff Reduction Weights

Since the Drive-Thru POD provides no added benefit in term of staff reduction as determined by our upper and lower bounds and the Pharmacy Option as well as the Door-to-Door Option provide 100% staff reduction it can be easily determined that the change in the weight of percent staff reduction will have no significant effect on the model. The increase and decrease in overall effectiveness of Pharmacy Option and Door-to-Door options will be directly proportional to the increase/decrease in weight. There will be no break point in this scenario.

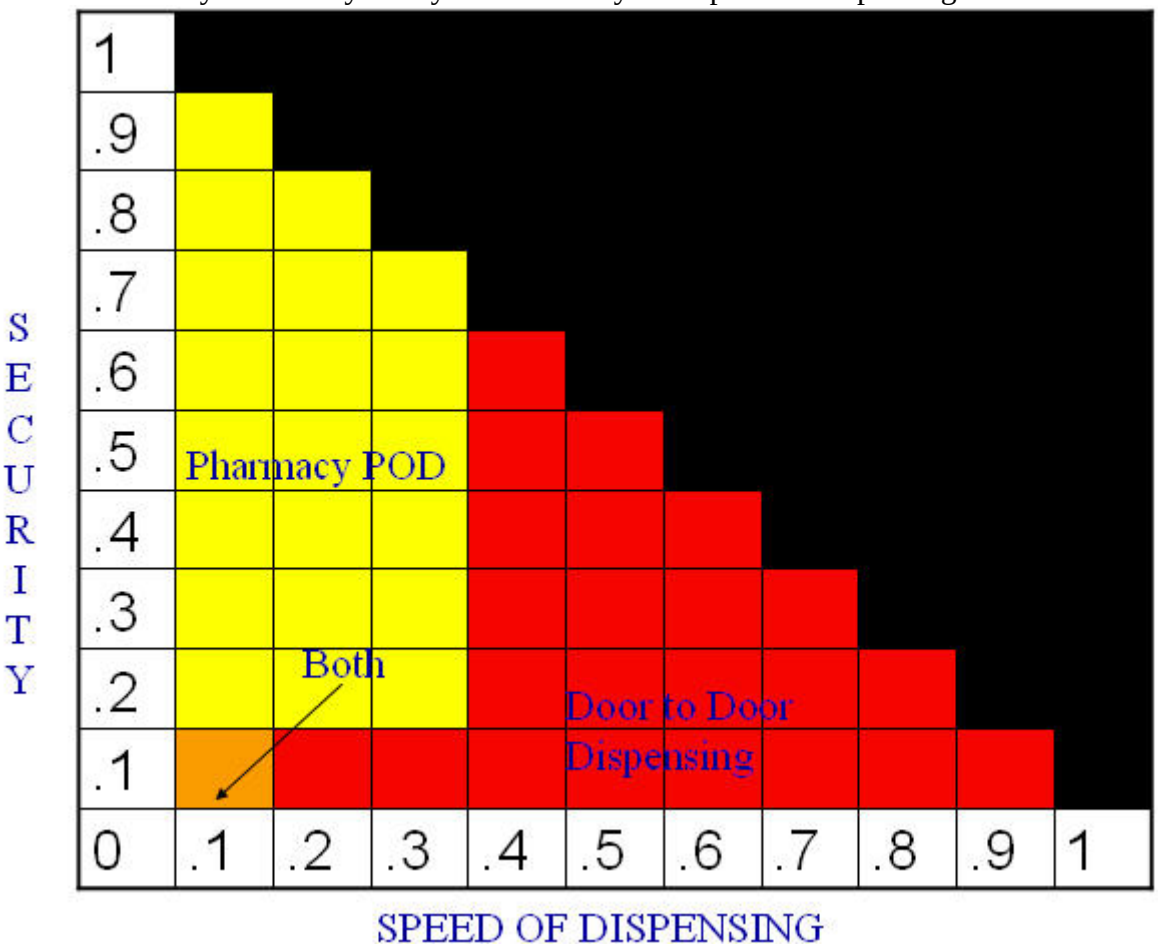
4. Two-Way Sensitivity Analysis of Weights

A two-way sensitivity analysis of weights is performed to understand how the overall effectiveness of all alternate modes of dispensing changes when the weights of two attributes are changed simultaneously. It is important to determine the change in the model based on all possible combination of attributes. However, as we determined in our

one-way sensitivity analysis, change in the weight of staff reduction has no effect on the effectiveness of alternate modes of Model A. Therefore only one two-way analysis, between speed of dispensing and security, was performed for Model A.

In order to perform a two-way analysis between speed of dispensing and security assessment a grid analysis was required, as shown in Figure 9. For example if the orange cell marked 'both' shows the weight of security at .1 and speed of dispensing at .1, by default the weight of percent staff reduction will be .8 in this scenario (recall that all weights must add up to 1). The change in weights of both options was observed at various points. The color coded boxes show the range of weights where a given alternate mode of dispensing would be a better choice over others. The black region shows the area where the sum of weights is greater than one, and therefore not applicable.

Figure 9. Two-way Sensitivity Analysis of Security and Speed of Dispensing for Model A.



If the weight of speed of dispensing and security are extremely low it is hard to justify choosing one option over the other. When the weight on security increases and the weight on speed remains relatively low the Pharmacy Option becomes a much better option, but when this situation is reversed, the Door-to-Door option becomes the more effective option.

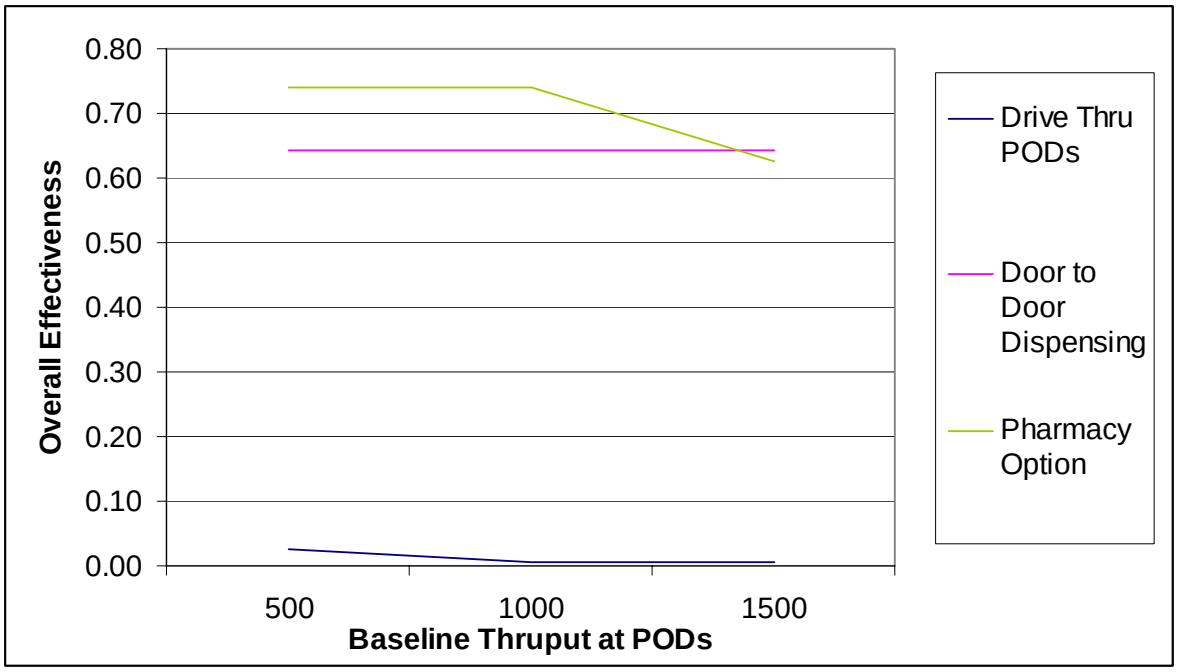
5. Analysis of Assumptions for Model A

Since most alternate modes of dispensing have never been tested it is necessary to estimate values such as the number of pharmacies that are being utilized in the Pharmacy Option. In a real contract these numbers can vary and it therefore becomes necessary to understand how the changes in these numbers affect the output of the model.

a. Changes in POD Baseline

The traditional POD option has been tested on several occasions. Since the traditional POD is used as a baseline to set the upper and lower bounds of our analysis, it is important to assess the impact a change in speed of POD will have on our output. Model A was run using the throughput values of 500, 1,000 and 1,500 people per hour and the upper and lower bounds of speed were adjusted accordingly. The output is shown in Figure 10. If the throughput at PODs in LAC is lower than 1000 people per hour, then the Pharmacy Option is the optimal alternate dispensing solution. As the thru put at PODs increases over 1000 people per hour the overall effectiveness of the Pharmacy option decreases. A cross over point between the pharmacy option and the door to door dispensing option appears at around the throughput of 1300 people per hour. A through put above this point results as the pharmacy option become a less effective option as compared to the door to door dispensing option. The overall effectiveness of the door to door option does not seem to be influenced greatly by changes in through put. While lowering the classic POD speed makes the Drive-Thru Option more appealing, it is still not a good option for LAC.

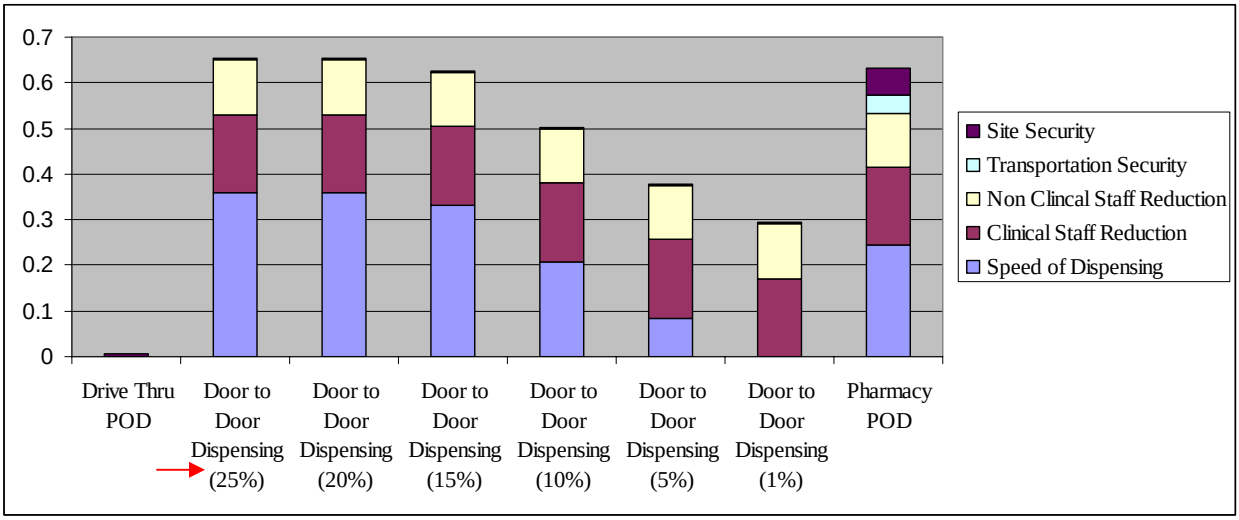
Figure 10. Effects of the Change in Baseline for Model A.



b. Changes in the Number of Postal Carriers

In the assessment for LAC we assumed that 25% of the required 3750 workforce of postal carriers reported for duty (Indicated by the Red Arrow in Figure 11). Increasing the percent of postal carriers will not affect the overall efficiency because at 20% the speed is already higher than the upper bound. However, it is important to understand how the output would change if the number of postal carriers reporting for duty is reduced. To test the assumption the model was run several times by reducing the workforce by 5% and finally at 1%. The output is shown in Figure 11.

Figure 11. Effects of Change in the Number of Postal Carriers in Model A.

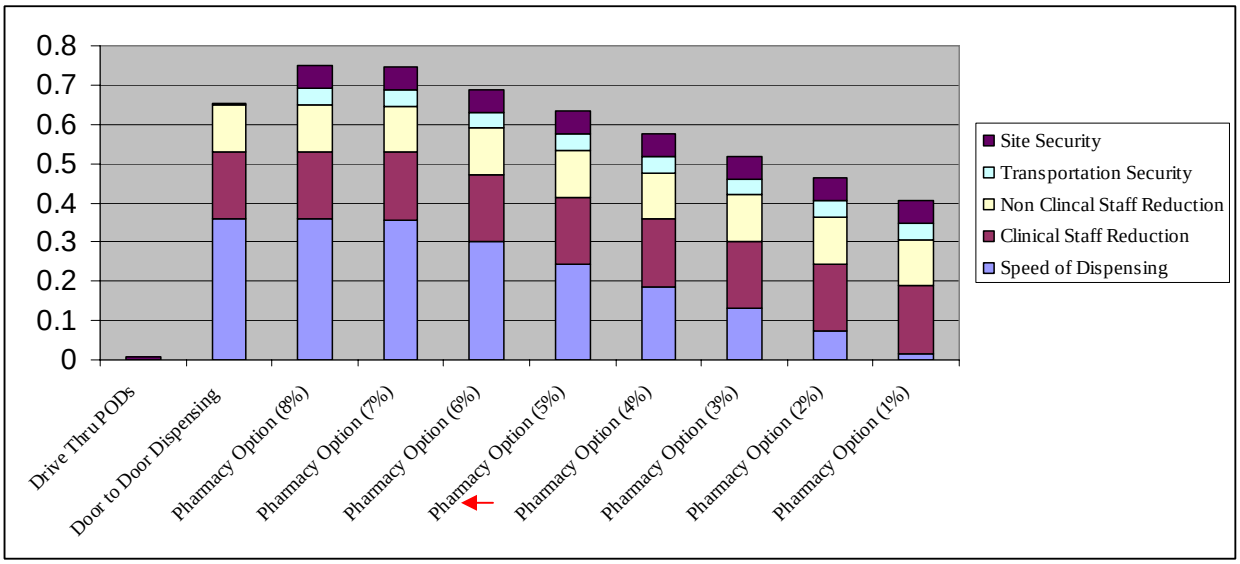


If fewer than 15% of postal carriers report for duty then the Door-to-Door option drops below the Pharmacy Option. However, even if only 1% of postal carriers report for duty, the Door-to-Door option is still much more efficient than the Drive-thru option and the traditional POD as it provides 100% reduction in staffing.

c. Changes in the Number of Pharmacies Dispensing Prophylaxis

For the Pharmacy Option, the model assumed that LAC can obtain a contract with 5% of the 1700 pharmacies in LAC (Indicated by the Red Arrow in Figure 12). It is important to test this assumption and assess the effects on the output if the number of pharmacies that has been contracted increases or decreases. The effects of increasing and decreasing the number of pharmacies by increments of 1% are shown in Figure 12.

Figure 12. Effects of Changes in the Number of Pharmacies in Model A.



If the number of pharmacies is increased by one percent, then the Pharmacy Option becomes the best alternate mode of dispensing. Even if only one percent of pharmacies in LAC are used the option is still better than the Drive-Thru POD and traditional POD options as it still provides a higher speed, 100% reduction in staffing and added security benefits.

As seen after performing all analysis for Model A, the Drive-Thru option under no scenario is a viable option for LAC, because it provides no added benefit in terms of speed of dispensing, percent reduction in staffing and security.

B. MODEL B

Model B serves specific subsets of the population of the county. There are eight alternate modes of dispensing that fall into this category. The baseline for comparison is the classic POD.

1. Pre-positioning of Medications for Government Employees and their Families (Civil Service Option)
2. Pre-positioning of Medications for Hospital Patients, Staff and Families of the Staff (Hospital Option)

3. Dispensing of Medications at Private Businesses (Private Sector Option)
4. Dispensing of Medications to SIPS Option
5. Dispensing of Medications to Students at Colleges and Universities (University Option)
6. Dispensing of Medications to Hotel Chains for their Guests, Employees and Families of Employees (Hotel Option)
7. Dispensing of Medications to Members of Kaiser Permanente (Kaiser Option)
8. Door-to-Door Dispensing (Door-to-Door Option)

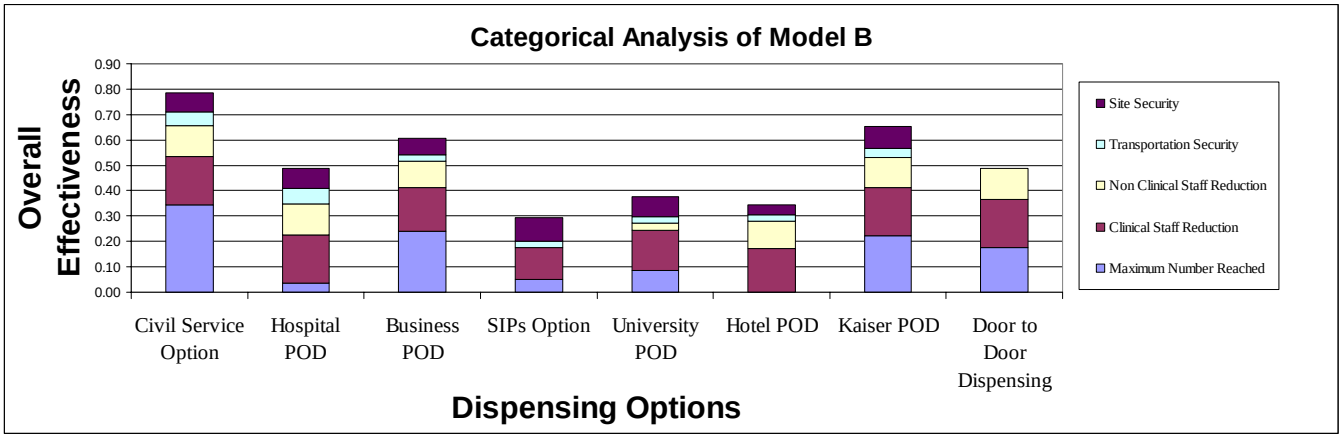
1. Baseline Analysis Based on Weights and Security Assessment of Law Enforcement Only

Based on our baseline analysis using average weights for each criteria as provided by the members of the FPC we found that the Civil Service Option had the highest overall effectiveness followed by the Kaiser Option. The two options that had the lowest overall effectiveness were the SIPS Option and the Hotel Option. To see the overall effectiveness for each alternative see Table 10 and Figure 11.

Table 10. Summary of Baseline Analysis for Model B.

Alternate Modes of Dispensing	**Maximum Number Reached**	**Percent Staff Reduction**		**Security**		**Overall Effectiveness**
		% Clinical Staff Reduction	*% Non-Clinical Staff Reduction*	*Transportation Security*	*Site Security*	
Civil Service Option	0.35	0.19	0.12	0.05	0.08	0.79
Hospital POD	0.04	0.19	0.12	0.06	0.08	0.49
Business POD	0.24	0.17	0.10	0.03	0.06	0.60
SIPs Option	0.05	0.13	0.00	0.03	0.10	0.30
University POD	0.09	0.16	0.03	0.03	0.08	0.38
Hotel POD	0.00	0.17	0.10	0.03	0.04	0.35
Kaiser POD	0.22	0.19	0.12	0.03	0.09	0.65
Door-to-Door Dispensing	0.18	0.19	0.12	0.00	0.00	0.49

Figure 13. Categorical Baseline Analysis of Model B.



All options have an overall effectiveness higher than the traditional POD. Four of the eight options provide LAC with 100% reduction in clinical and non-clinical staffing.

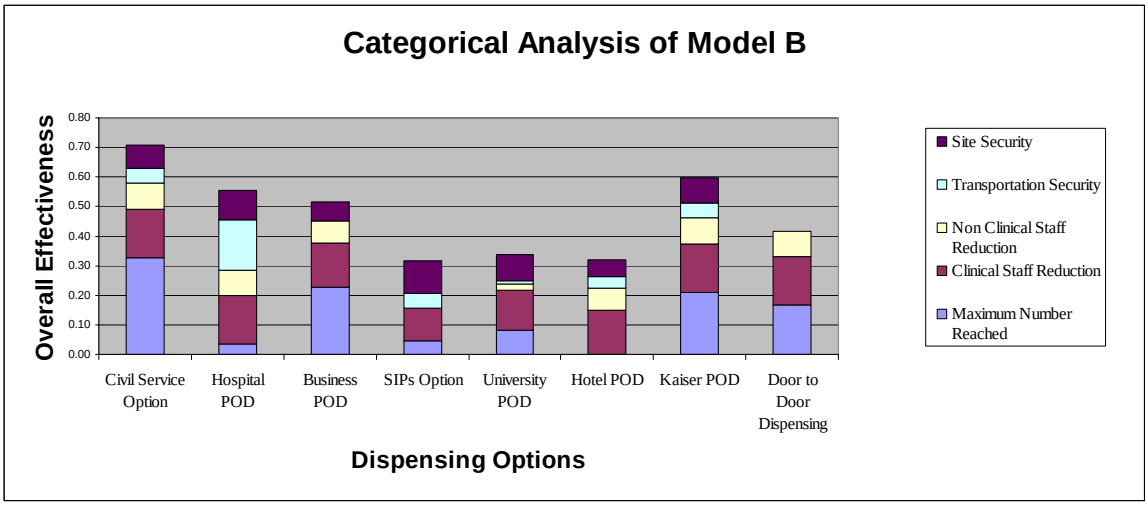
2. Based on Weights and Security Assessment of Law Enforcement Only

Based on the security assessment and weights of Law Enforcement representatives of the FPC, the Civil Service Option and the Kaiser POD are still the top two options. However, the overall effectiveness of both options is lower than our baseline. The overall effectiveness of the Hospital Option, University PODs and SIPS Option has increased. The major difference based on the comparison of Law Enforcement inputs and the entire FPC input is that according to Law Enforcement representatives, the Hospital Option would have a higher overall effectiveness than the Business POD. See Table 11 and Figure 12.

Table 11. Summary of Law Enforcement Analysis for Model B.

Alternate Modes of Dispensing	**Maximum Number Reached**	**Percent Staff Reduction**		**Security**		**Overall Effectiveness**
		% Clinical Staff Reduction	*% Non-Clinical Staff Reduction*	*Transportation Security*	*Site Security*	
Civil Service Option	0.33	0.16	0.09	0.05	0.08	0.71
Hospital POD	0.04	0.16	0.09	0.17	0.10	0.56
Business POD	0.23	0.15	0.08	0.00	0.06	0.51
SIPs Option	0.05	0.11	0.00	0.05	0.11	0.31
University POD	0.08	0.14	0.02	0.01	0.09	0.34
Hotel POD	0.00	0.15	0.08	0.04	0.06	0.32
Kaiser POD	0.21	0.16	0.09	0.05	0.09	0.60
Door-to-Door Dispensing	0.17	0.16	0.09	0.00	0.00	0.42

Figure 14. Categorical Law Enforcement Analysis for Model B.



3. One-Way Sensitivity Analysis of Weights

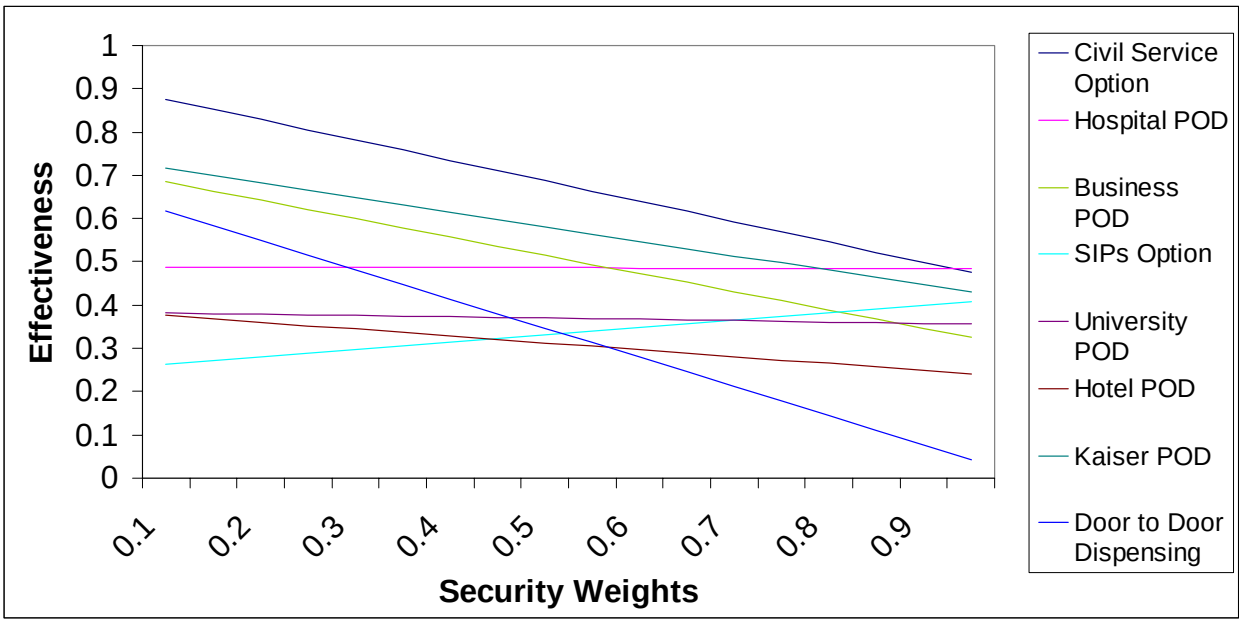
Recall that a one-way sensitivity analysis of weights looks at the overall effectiveness of all alternatives when the weight of one attribute is changed, leaving the other two proportionally constant. The analysis will first assess the effects of the change in the weights for security, followed by percent staff reduction and finally maximum numbers reached by increasing the weight for the selected attribute in increments of .05 between .1 and .95.

a. Based on Security Weights

As seen in Figure 13, the top three options (the Civil Service Option, Business POD and Kaiser POD) as seen in our baseline are negatively influenced by an increase in the weight for security. However, the Civil Service Option remains the most effective option and is matched by the Hospital POD option at the weight of .95. A few important breakpoints are brought to light in the analysis. If the weight on security is higher than .8 it would be fairly difficult to make a recommendation between the Kaiser POD, Civil Service Option and the Hospital POD Option. At a weight of .6 it would be fairly difficult to judge the third best option between the Hospital POD and the Business

POD Options. However, if the weight on security in LAC is below .55 then the top three options are the Civil Service Option, Kaiser POD Option and the Business POD Option.

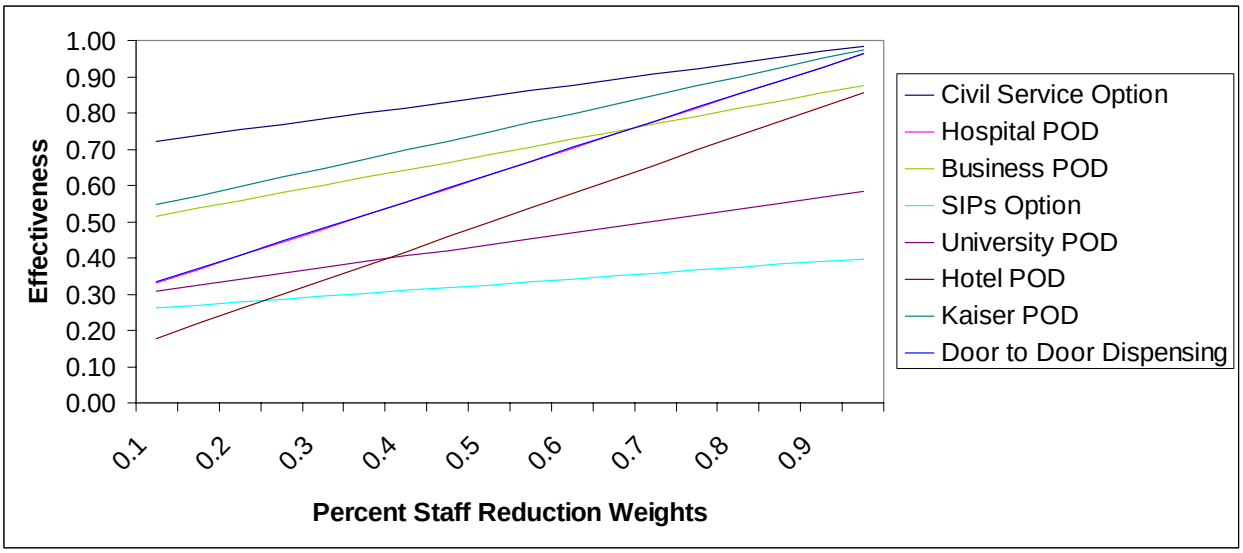
Figure 15. One-way Sensitivity Analysis of Security Weights for Model B.



b. Based on Percent Staff Reduction Weights

As seen in Figure 14, an increased weight on staffing increases the overall effectiveness of all alternate modes of dispensing. The top three options, if the weight on percent staff reduction is below .67 are the Civil Service Option, Kaiser POD Option and the Business POD Option. However, there is a break point at .67 above which the Business POD is no longer the third best option and is replaced by the Door to Door dispensing option.

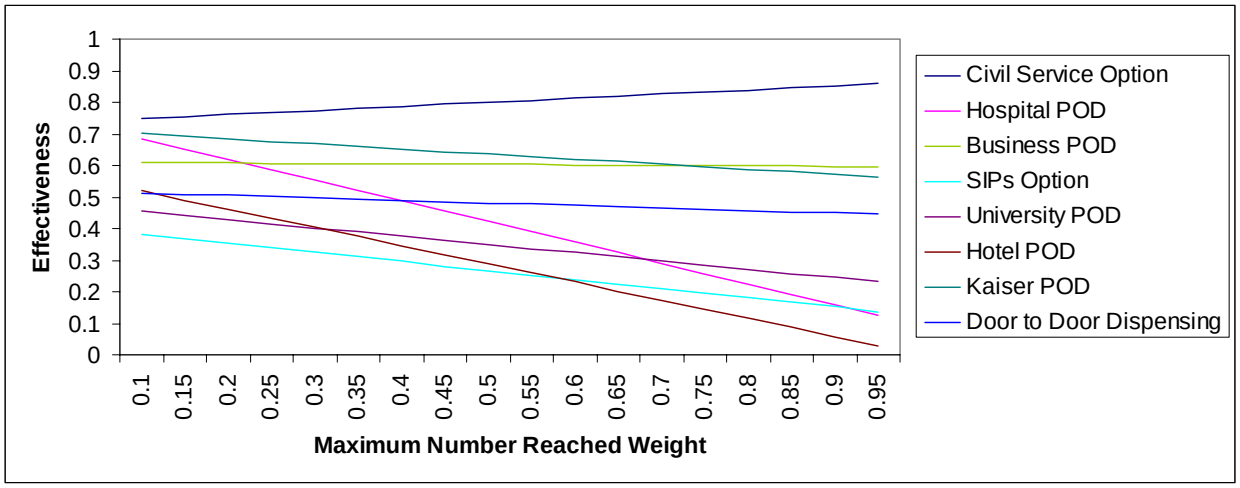
Figure 16. One-way Sensitivity Analysis of Percent Staff Reduction for Model B.



c. Based on Maximum Number Reached

As shown in Figure 15, the Civil Service Option is least affected by the change in weight for the maximum number reached and would therefore be the most optimal option at any weight for this attribute. The Kaiser POD, Business POD and Hospital POD Option are all negatively influenced by an increase in the weight of this attribute. There are some important break points that have come to light in this analysis. If the weight for maximum number reached is low it will be difficult to judge between the Hospital POD and Business POD Options as their break point is at approximately .23 and either could be one of the top three options. At the other end of the spectrum if the weight for maximum number reached is around .75 then the Kaiser POD or the Business POD could be the second best option after the Civil Service Option. As the weight on maximum number reached increases the effectiveness of the Hospital POD drops precipitously.

Figure 17. One-way Sensitivity Analysis of Maximum Number Reached for Model B.



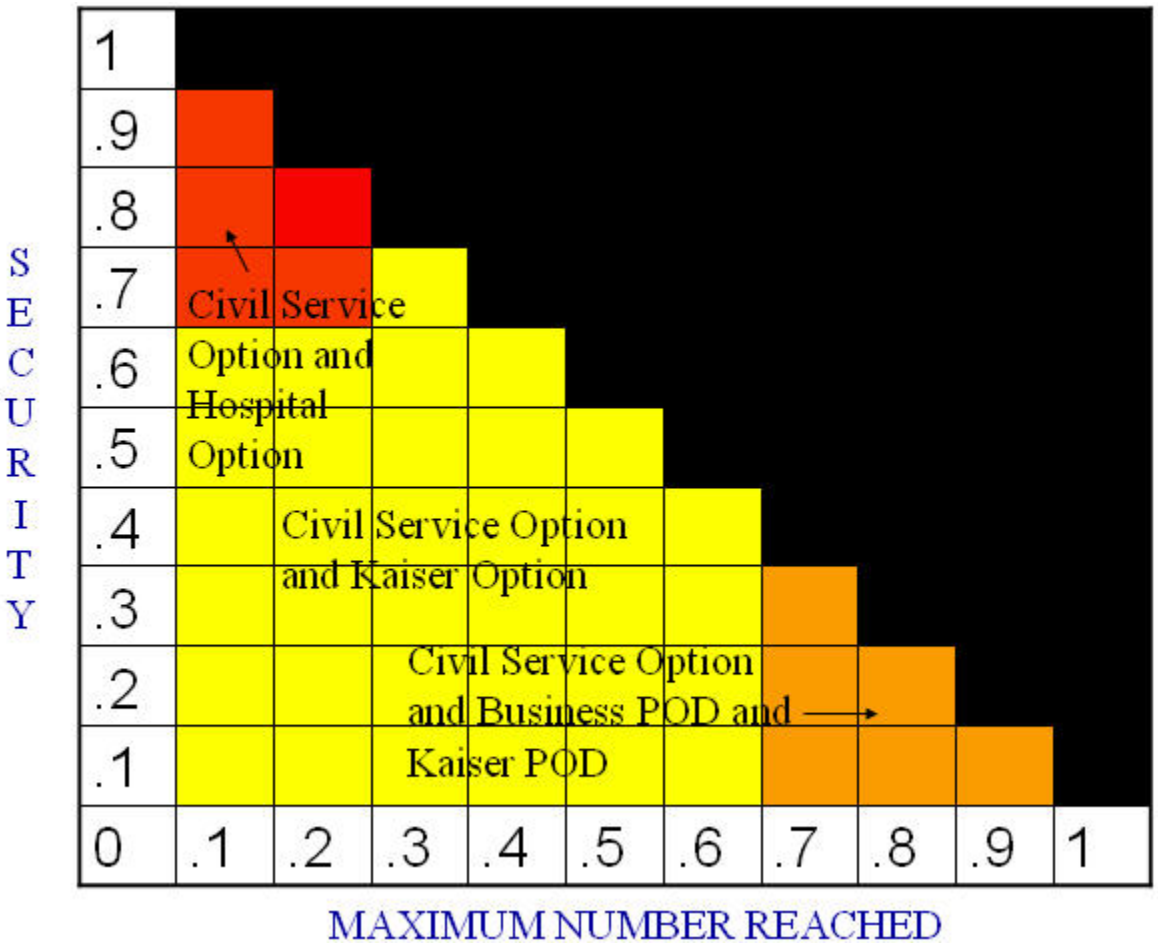
4. Two-Way Sensitivity Analysis of Weights

Recall that a two-way sensitivity analysis of weights is performed to understand how the overall effectiveness of all alternate modes of dispensing changes when the weights of two attributes are changed simultaneously. The analysis is similar to that of Model A, but all three combinations of attributes were tested in Model B. The shading in the grid represents the top two options unless otherwise noted.

a. Based on Security and Maximum Number Reached Weights

As shown in Figure 16, the Civil Service Option and the Kaiser POD are the top two options regardless the weight on the maximum number reached when the weight on security is medium to low. When the weight on the maximum number reached is high, the Business POD Option becomes a viable choice. Finally when the weight on security is higher, the Hospital POD Option replaces the Kaiser POD Option as one of the top two choices.

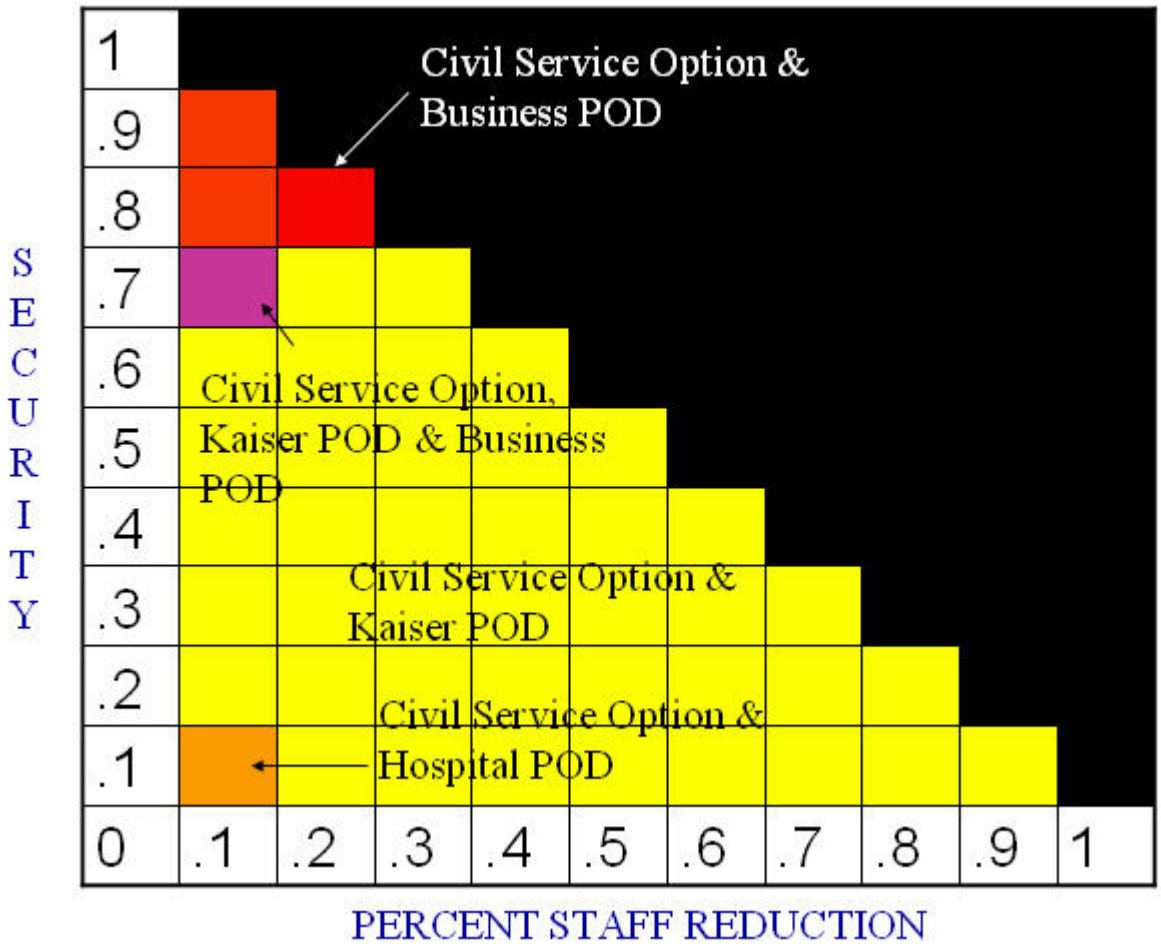
Figure 18. Two-way Sensitivity Analysis of Security and Maximum Number Reached for Model B.



b. Based on Security and Percent Staff Reduction Weights

As seen in Figure 17, when the weights on security and percent staff reduction are extremely low, the top two choices are the Civil Service Option and the Hospital POD. As the weight on percent staff reduction rises above .1, the Civil Service Option and the Kaiser POD will be the top two choices regardless of the weight on security. When the weight on security increases above .6 and on percent staff reduction remains low the Business POD Option begins to replace the Kaiser POD Option as the top two choices.

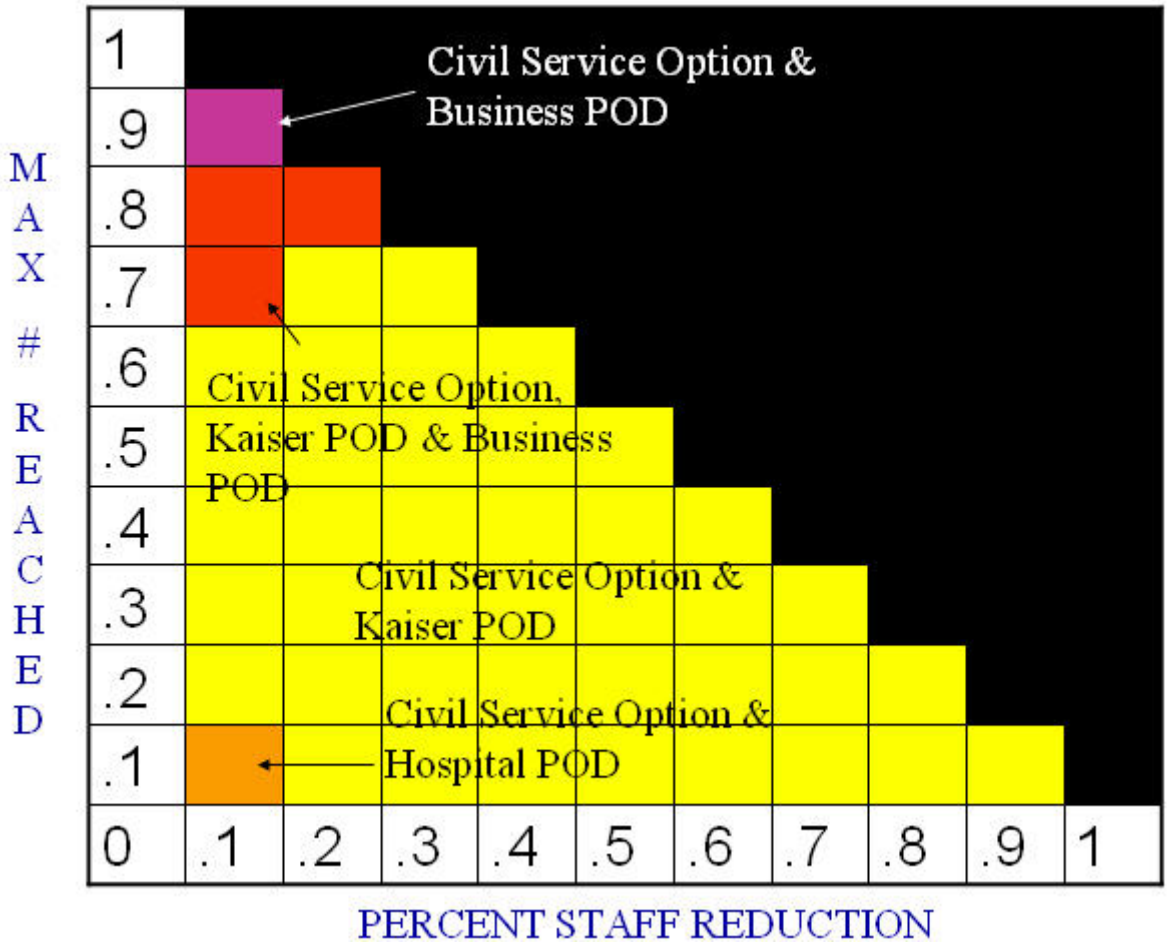
Figure 19. Two-way Sensitivity Analysis of Security and Percent Staff Reduction for Model B.



c. Based on Maximum Number Reached and Percent Staff Reduction Weights

As seen in Figure 18, when the weights on maximum number reached and percent staff reduction are extremely low, the top two choices are the Civil Service Option and the Hospital POD. As the weight on percent staff reduction rises above .1, the Civil Service Option and the Kaiser POD will be the top two choices regardless of the weight on the maximum number reached. When the weight on maximum number reached increases above .6 and on percent staff reduction remains low the Business POD Option begins to replace the Kaiser POD Option as the top two choices.

Figure 20. Two-way Sensitivity Analysis of Maximum Number Reached and Percent Staff Reduction for Model B.



5. Analysis of Assumptions for Model B

Since traditional PODs also served as the baseline for Model B it is essential to test the effects of the change in POD throughput on the output of Model B. The model was run assuming throughputs of 500 people per hour and 1,000 people per hour. However, no significant changes were observed in the output as compared to the baseline.

C. SUMMARY OF RESULTS

As seen in Model A, unless the weights for speed of dispensing and security are at extremes it is difficult to justify either the Door-to-Door Option or the Pharmacy Option more efficient than the other. As seen in Model B, the Civil Service Option will always be the most effective for LAC, followed closely by the Kaiser POD Option. However, when security and maximum number reached approach extremely values, the Hospital POD Option and the Business POD Option begin to compete with the Kaiser POD Option as the second most effective.

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VII. DISCUSSION

This chapter discusses the uncertainty of data in Model A and Model B and determines that the results obtained in Chapter VI are robust and applicable. The chapter also provides a discussion on the acceptability of results, pitfalls that LHDs must consider as they develop portfolios of various options, considerations with respect to the special needs population, and ensuring that the gaps left behind by the POD-based approach are addressed by the alternate modes of dispensing. Finally, this chapter identifies barriers and solutions to implementation of the results, provides a scope for future research, and presents the conclusion of this research.

A. UNCERTAINTY OF DATA

Since most alternate modes of dispensing have never been tested, it is difficult to derive the numbers for speed of dispensing and staffing, both clinical and non-clinical, as needed in Model A. Most of the numbers were derived by mathematical analysis and comparison of the alternate mode of dispensing to the traditional POD in a given LHD's jurisdiction. Similarly it is difficult to ascertain the exact value of the maximum number reached and staffing as required in Model B. It is impossible to estimate the exact number of partners (be it cities in the Civil Service Option or Private Businesses in the Business PODs option) that would like to partner with the LHD in mass prophylaxis until an official MOU is signed between agencies. At the same time the number of employees in the partner agencies is dynamic and hard to track accurately. Staffing requirements during a mass prophylaxis event also may not be accurately estimated until MOU's are signed. This is because some large employers or large universities may not have the medical staff to prophylax everyone and may require help from the LHD. Similarly, the weights and security ratings are averages of an individual decision maker preference and therefore susceptible to change.

Since establishing accurate values can be time consuming and expensive, an optimal solution can be to estimate raw values of speed of dispensing, maximum number

reached and staffing for a preliminary analysis and then test the susceptibility of the output to change. This approach was used in Chapter VI via sensitivity analysis and testing assumptions.

1. Model A – Sensitivity Analysis and Assumptions

Recall that a one way sensitivity analysis was performed in Model A for each attribute by gradually increasing the weights of an attribute by increments of .05 from .1 to .95. As seen in Chapter VI, when the weight of security was assessed, a breakpoint (a point where two options cross each other for overall effectiveness) arose. If the security weights are low (i.e. security is deemed less important with respect to speed and staffing requirements), the door to door option is the preferred option, but if the security weights are high (i.e. security is deemed more important with respect to speed and staffing requirements) then the pharmacy dispensing option is the preferred option. This is because the security requirements (assessed on a scale of one to ten) are much higher for the door to door dispensing option as compared to the pharmacy option thereby influencing both options at different rates and creating the breakpoint. When the attribute 'speed of dispensing' was assessed, another breakpoint appeared. If speeds of dispensing weights are low (i.e. speed is deemed less important with respect to security and staffing requirements) then the pharmacy option is the preferred option, but if the speeds of dispensing weights are high (i.e. speed is deemed more important with respect to security and staffing requirements) then the door to door option is the preferred option. This is because the speed of dispensing for the pharmacy option is lower than that of the door to door dispensing option. These results were also seen in the two way sensitivity analysis between security and speed of dispensing. When the weights for both attributes are low, both options seem equally efficient. However, when security weights are from moderate to high the door to door dispensing option is confirmed as the best option, however, when the weights for speed of dispensing are high the pharmacy option is confirmed as the best option. When the weights between speed and security are approximately equal, the top two options are approximately equal as well. A change in the weight for percent staff

reduction does not influence the outcome because both options provide 100% staff reduction both clinical and non clinical staff. The influence of all weights on the drive thru dispensing option is negligible.

Since some of the values used in the analysis were based on certain assumptions, it was essential to estimate the effects on the outcome if our assumptions were manipulated. Our first assumption was the speed of dispensing at each point of dispensing that was used to set our upper and lower bounds. The door to door dispensing option seemed to be independent of any changes to the baseline speed of dispensing between 500 people per hour and 1500 people per hour. The pharmacy option's overall effectiveness began to decrease when the speed of dispensing was higher than 1000 people per hour. Finally, there was a breakpoint at around 1300 people per hour where door to door dispensing became the most efficient option. The drive thru option failed to significantly change based on changes in baseline.

A second assumption in Model A was that LAC had only 25% of the 3,750 workers needed to dispense medication door to door. The model was run several times by reducing the workforce by 5% and finally at 1%. At baseline the door to door option was the best option but dropped just below the Pharmacy option when the workforce was reduced to 15%. With the workforce at 1% the door to door dispensing option was still the second best option, and was still a much better option than drive thru dispensing.

The final major assumption in Model A was the use of 5% of pharmacies in Los Angeles County. This number is dynamic and therefore will not be set till all MOUs have been signed between pharmacies and LAC. As seen in our analysis when the number of pharmacies available is increased by only 1% the pharmacy option becomes the most optimal option. Finally if only one percent of pharmacies are used the pharmacy option is still a much better option than the drive thru POD.

Therefore, as seen in the sensitivity analysis and testing of assumption the output of data from Model A is robust. Drastic changes in the input do not have drastic changes in the output making the model less susceptible to change. Therefore, although the data may have some uncertainties, the Door to Door option and the Pharmacy Option are the two best options in LAC to dispense medications to the general public. The drive thru

option is the worst option in LAC. Given the baseline values, the top two options are practically indistinguishable. If there is a need to distinguish between them more detailed data with a great precision of accuracy is required. However, other characteristics not captured in the model may guide the final choice and either option would be acceptable.

2. Model B – Sensitivity Analysis and Assumptions

As seen at baseline in Model B, the Civil Service Option, Business POD and Kaiser POD are the top three options in terms of overall efficiency. According to the one way sensitivity analysis of the security weights, the civil service option and the Kaiser POD will remain as two of the top three options no matter what the weight on security. The hospital POD would replace the Business POD as the third option at very high weights of security. This is because the security rating (based on the scale of one to ten) for the Business POD is higher than that of the hospital POD. When one way sensitivity analysis is performed on the weights of percent staff reduction, the top three choices are the Civil Service Option, Business POD and Kaiser POD, with the Door to Door dispensing option replacing the Business POD option at extremely high weights. This is because the door to door option requires no staff, as defined in Chapter IV, where as the Business POD option requires running of a small warehouse like operation. When one way sensitivity analysis is performed on the weights of maximum number reached the top three options are still Civil Service Option, Business POD and Kaiser POD except at very low weights where Business POD is replaced by the Hospital PODs as the most efficient option. Although the third best option changes based on the scenario, it is set that the Civil Service Option and Kaiser POD work well at any weight of any attribute.

As seen in the two way sensitivity analysis of all three possible combinations of the attributes, the Civil Service Option and the Kaiser Option all grids with an additional option appearing at the extremes (See Figure 18, 19 and 20). Therefore, the Civil Service Option and the Kaiser POD are worth developing under any circumstance as they are not influenced significantly by drastic changes in weights of any attribute.

A major assumption that was seen in Model B was the upper and lower bounds were based on the traditional POD data. Upon changing the baseline POD thru put no

significant change were observed in the model. Therefore the output of Model B in this case is independent of the changes in POD data.

As seen thus far, the uncertainties of data can be addressed by sensitivity analysis and testing of assumptions. This analysis answers the 'what if?' question and shows decision makers how prone their conclusion is to change. Even though there are uncertainties and assumptions in our data they do not influence the outcome of Model A or Model B. The top options in both models remain the same even after drastic changes to the input values thus making these uncertainties irrelevant. As see in Model A and Model B the top options remained the same under a full range of weights and drastic values of all assumptions. We can therefore confidently conclude that our results are very robust and therefore the uncertainties are less worrisome.

B. ACCEPTABILITY OF RESULTS

Recall that security assessments and weights in our example were obtained using a survey that was administered to the FPC in LAC that is comprised of over 50 members. However, only 17 members attended the session where the survey was administered along with a short presentation. The rest of the members received the presentation and survey via email along with a brief letter explaining the purpose. None of the members that received the survey via email returned their responses. At the same time, of the seventeen members that did attend the session two members from the law enforcement community refused to participate in the survey for personal reasons, leaving only fifteen viable surveys. LHDs that plan to implement this process should increase this sample size by administering this survey to several emergency preparedness and force protection committees as well as other stakeholders in the mass prophylaxis process. Increasing this sample size will provide a more representative view of security assessment as well as weights of various attributes.

Furthermore in order to obtain interagency buy-in all stakeholders should be involved in the process to develop the objective hierarchy. As seen in the section above the preliminary results obtained from our analysis are robust, valid and applicable. However, they solely represent the public health point of view. Involving stakeholders early in the process will give all stakeholders an equal opportunity to voice their concerns

during the creation of the objective hierarchy. The new hierarchy developed by consensus may contain attributes that do not reflect public health concerns, but having buy-in from all stakeholders can greatly reduce complications during implementation.

C. PORTFOLIOS

If LHDs have enough resources, they may choose to implement a portfolio of alternate modes of dispensing. In Models A and B, the alternate modes of dispensing were evaluated as separate, stand-alone options. Portfolio analysis raises a number of issues such as double counting of the numbers that can be reached. For example, recall that for LAC the most effective options under Model B were the Business POD Option and Kaiser POD. The next best alternatives were the Civil Service Option and Hospital POD. Kaiser Permanente, which is a major HMO in LAC, would provide prophylaxis to all its members, staff and their families. In LAC several large businesses that may be targeted by the Business POD option provide health insurance to their employees via contracts with Kaiser Permanente. Similarly, many civil service agencies provide health insurance to their employees via Kaiser Permanente. Kaiser Permanente also owns hospitals in LAC, and Kaiser is also one of the top 25 employers in LAC. Since Kaiser Permanente influences several other options if a portfolio is created using the top four options, it is important for decision makers not to overestimate the number of people that can be reached using the portfolio. Under counting can also be an issue in a portfolio, because the USPS Option only provides individuals with the initial doses of the prophylaxis in order to buy time for LHDs to establish PODs. Therefore if an LHD chooses to incorporate multiple options in their jurisdiction as their mass prophylaxis strategy, they must be aware of this issue to correctly estimate how many people may be prophylaxed outside of PODs. Nevertheless, portfolios are important in major metropolitan areas that have a higher than average population because a combination of options may be required to sufficiently reduce the pressure on PODs. However, decision makers must be careful in estimating the extent of this reduction when using a portfolio.

D. SPECIAL NEEDS POPULATION

As seen so far, the SIPs option in Model B is the only option that serves the special needs population in LAC. The SIPs option is unique compared to other options because it serves a population that is not targeted by any other option. Similarly during an emergency the special needs population in LAC may face many logistical barriers getting to the closest POD. In the worst case scenario like Katrina, there is a fear that those responsible for caring for the special needs population may abandon them in order to protect themselves and their families (Vestal, 2005). Even if the members of the special needs population have access to modes of transportation to the POD, they may have to wait for several hours outside exposed to the elements in order to obtain their medications, unnecessarily putting their health at risk. (Los Angeles County Operation Chimera, 2003). The SIPs option has fairly low staffing and security requirements and serves a population that is in need of critical care during an emergency as seen during Katrina (Vestal, 2003). Therefore, although the SIPs option is not seen as an efficient option for mass prophylaxis, it may very well be the only means of providing prophylaxis to the special needs population in LAC. The SIPs option should therefore be given special consideration and implemented in LAC.

E. HAVE MASS PROPHYLAXIS CHALLENGES BEEN ADDRESSED BY ALTERNATE MODES OF DISPENSING?

Recall from Chapter II that the third annual report, *Ready or Not? Protecting the Public's Health from Disease, Disasters and Bioterrorism*, the Trust for America's Health determined that LHDs are significantly under- prepared to respond to bioterrorism events. Eighty five percent of the states as well as the federal government received a failing grade for activities related to bioterrorism preparedness and response (Trust for America's Health, 2006). Engaging communities using alternate modes of dispensing will increase public awareness and help LHDs prepare to respond to a large scale bioterrorism attack by sharing responsibility.

The responsibility to provide public health service in the United States mostly lies with the LHD, because the federal government and most states have planning and advisory roles. As seen during the smallpox campaign, LHDs do not have the

infrastructure to support mass prophylaxis (Santiago, 2006; Mitchel, 2005). Building relationships with major businesses, HMOs, Universities and other local governments can help reduce this gap in infrastructure by utilizing previously untapped resources. For example, LHDs may not be able to find suitable sites to serve as PODs, but utilizing alternate modes of dispensing they may not need as many sites.

Similarly LHD are typically understaffed to run daily functions and there is massive surge in the need for staff during an emergency. This means that POD staffing will be completely dependant on volunteers (Flynn, 2004). Since LHDs have only 48 hours to prophylax their entire population, staff procurement issues can be particularly burdensome. Due to this constraint, most LHDs will not be able to set up and operate all PODs at once further shrinking the time window available for prophylaxis. Additionally, LHDs must deal with credentialing, training and spontaneous volunteers. Using alternate modes of dispensing reduce, if not completely eliminate, these problems. Corporations typically maintain personnel files which include credentialing of their staff, they have updated call down rosters for all their staff as a part of their business continuity plan. Since they would be involved in the planning and response processes it would be their responsibility to set up PODs and procure staffing, reducing the pressure on LHDs. In almost all cases, family members will be provided with prophylaxis, thus encouraging employees to return to work and minimize losses for corporations.

Since the security requirements at a POD are directly proportional to the number of people coming to PODs, alternate modes of dispensing will reduce pressure on local law enforcement agencies and reduce traffic control issues. Corporations typically have contracts with private security service firms and this could be a great opportunity to build a partnership between the two by sharing security responsibilities.

F. BARRIERS AND SOLUTIONS TO IMPLEMENTATION

Once an LHD has established which alternate modes of dispensing will best serve the needs of their jurisdiction, based on the multi-attribute decision-making models discussed in this paper, it will face a new challenge regarding implementing its findings. As discussed by Chan and Mauborgne in the book, “Blue Ocean Strategy” it is difficult for any agency to create an operational plan from their strategic plan (Chan, 2005). This

is because putting ideas into motion, according to Chan and Mauborgne, involves four hurdles – cognitive, motivation, resource, and political. The problems posed by one hurdle and the solutions to it may often influence the problems posed by other hurdles (Chan, 2005).

The cognitive hurdle in this case deals with making the stakeholders aware of the issues that the traditional POD option faces today and the need for change (Chan, 2005). The largest and the most influential stakeholder by far in the preparedness efforts of this country is the community. The Oklahoma City/County Health Department faced this cognitive hurdle as they tried to implement their SIPs plan (Public Health Training Network, 2006). Their early attempts to make the stakeholder (the SIPs) community see the need for a SIPs plan were failures because they failed to explain to the community what they didn't understand (Public Health Training Network, 2006). Most nursing homes and assisted living facilities had in house physicians or pharmacists and they were under the impression that they would get their prophylactic medications from them. When this issue was brought to light, the health department informed them that the SNS was a federal asset and their contracted physician or pharmacist may not have enough drugs to prophylax all residents for an extended period of time. This single piece of information boosted the number of participants significantly (Public Health Training Network, 2006). However, this problem may not be isolated to SIPs plan only. Most large businesses, HMOs, government agencies, private hospitals and hotels provide health insurance to their employees. Similarly, colleges and universities provide student health insurance. They may not foresee the problems that may arise during an emergency as they may believe their employees can get their medications from their primary physician. Due to this single chain of thought they may not see the potential impact of a bioterrorism event on their day to day activities. Providing stakeholders with such critical information is key to sway their opinion and overcome this cognitive barrier. As noted by the Oklahoma City/County Health Department clear communication with decision makers in the community is key to overcome cognitive hurdles (Public Health Training Network, 2006).

The motivational hurdle deals with mobilizing stakeholders to take action (Chan, 2005). The question LHDs must ask themselves is what incentives or benefits will make stakeholders act. As stated earlier the largest stakeholder is the community. The sectors of the community that will be involved in the alternate modes of dispensing will often take cost benefit analyses of the shared responsibility into account. The Southern Nevada Health District (SNHD) that includes Las Vegas deals with a fluctuating population as Las Vegas has over 300,000 tourists on peak days (Public Health Training Network, 2006). They overcame the cognitive hurdle by making the resorts and casinos aware of the problem through a relationship with the 'Hotel Security Chiefs Association'(Public Health Training Network, 2006). However, this was not enough; they faced a motivational hurdle to get the resorts and casinos to partner up with them on this problem. Resorts and casinos completely depend on keeping their doors open to make profit. In order to achieve this they need two things, 1.) Staff to run the resort and 2.) People to stay at the resort and enjoy the activities offered in the casinos. In terms of a cost benefit analysis, the threat of a bioterrorism attack in Las Vegas is high; if a bioterrorism attack does take place the staff will potentially abandon their post and go to PODs to get prophylaxis for themselves and their families; finally panic will ensue and people will rush out of the resorts and casinos. This will lead to huge economic implications for the resorts and casino owners (Public Health Training Network, 2006). Keeping the casinos open to minimize economic loss would be in the best interest of the resorts and casinos. In order to do this, they need to provide prophylaxis to their staff and families as well as their guests. The resorts and casinos were now ready to share mass prophylaxis responsibility with the LHD by setting up a closed POD for employees, their families and their guests. Competition between businesses can be a good source to overcome the motivational barrier as seen in Las Vegas, when one business acts on an issue its lead competitors tend to follow (Public Health Training Network, 2006). If LHDs are successful in convincing one stakeholder there is a good chance that other competitors will follow.

The third hurdle to implementation is resources. Recall the argument by Flynn that due to state and local budget constraints most LHD are understaffed to run their daily

functions (Flynn, 2006). It may therefore not be possible for an LHD to create partnership with all potential alternate modes of dispensing stakeholders. This is especially true as some alternate modes of dispensing may have several stakeholder whose cooperation is required for the success of the option. For example, in LAC there are 402 skilled nursing homes and 1,280 residential care facilities, it would be a monumental task for the LHD to pull together all facilities (The Urban County CDBG Program, 2001). Similarly, if LAC is to pull together all civil service agencies, large businesses, businesses that deal with critical infrastructure, hospitals, colleges and universities or HMOs it will be a huge burden for the limited staff available. Hence knowing which mode to target first based on multi attribute decision analysis is critical. Las Vegas tried to overcome the resource hurdle by working with the 'Hotel Security Chiefs Association' that has representation from almost all resorts and casinos in Las Vegas (Public Health Training Network, 2006). Similarly LAC is trying to establish a relationship with the Business Executives for National Security (BENS) to communicate with all major businesses in its jurisdiction and to help "state/local business organizations and government leaders build their own self-sustaining regional partnerships" (BENS, 2007). As seen in our examples it is best to build a relationship with a single entity such as an organization that boasts your community stakeholders as its members.

The final hurdle and potentially the most difficult hurdle to overcome is the political hurdle. The best way to overcome this hurdle is make the political leaders into stakeholders by eliminating the cognitive hurdle on their part (Chan, 2005). To address equitability of response LHDs should maintain transparency that includes logical reasoning of their decision makers.

Any variance in the manner of delivery of the prophylaxis may be perceived as preferential treatment; therefore a strong public relations campaign is essential to obtaining political support. Once public acceptability is met, the political acceptability will follow. In all cases obtaining early buy in of political leaders, from all partnering agencies, can have a profound impact on this hurdle. Interagency support can flourish through strong political leadership that is willing to negotiate with other agencies and make concessions.

G. FUTURE RESEARCH

As this paper has shown thus far, alternate modes of dispensing are important solutions to the problems posed by POD-based mass prophylaxis problems and that multi attribute decision analysis is an important tool for LHDs to analyze which alternate modes of dispensing can be the most beneficial in their jurisdiction. However, there are still several issues surrounding alternate modes of dispensing that remain unanswered.

1. Costs

In order for LHDs to set up any alternate mode of dispensing they must incur certain costs associated with creating strategic and operational plans associated with each alternate mode of dispensing. The costs associated with alternate modes of dispensing break down into two major subcategories, preplanning costs and implementation costs. Preplanning costs are the costs associated with setting up an option, whereas implementation costs are the cost incurred when the option is implemented during an emergency. Both costs can be difficult to define, estimate or measure and can range from work-hours lost to the project, employee salary and benefits, contractor fees and travel. In the objective hierarchy seen in this paper, the cost of setting up an alternate mode of dispensing and implementing it was not considered. Nevertheless, these costs are an important attribute that is often taken into account by decision makers in the public and private sectors alike. Although cost of implementation may be overlooked during an emergency, it is very unlikely that public and private partners would ignore the need to estimate both costs during the preplanning phase. Therefore, further analysis is necessary to accurately estimate the cost of alternate modes of dispensing.

2. Cost-Benefit Analysis

LHDs and partners involved in alternate modes of dispensing may experience several benefits from cooperation in mass prophylaxis efforts. For the LHDs the partnership makes the problem a community oriented problem and organizes private partners fill the gaps that LHDs may not be able to. This partnership also reduces the pressure on PODs by reducing the over dependency on volunteers to staff them and

reducing the number of people going to PODs. This indirectly also reduces pressure on law enforcement as some options require minimum security or provide for private security. On the other hand, it keeps business running with a sense of normalcy in the wake of a bioterrorism attack, reduces employee absenteeism and improves the relationship between private businesses and their community/workforce. But all these benefits come at a cost. Politically, LHDs may be accused of favoritism for exercising one option and not the other. LHDs may be dragged into litigations due to the negligence of partner agencies during mass prophylaxis. Similarly, partner agencies face litigation from injuries occurring from medications or at the dispensing site. Businesses from the private sector must also consider the social stigma of many potentially infected individuals coming to their sites to collect medications. Private partners must also consider the position of their insurance companies that may revoke their insurance claims resulting from injuries as dispensing medications is not a part of their normal operations (Smith, 2007). There is not doubt that LHDs and partner agencies benefit from the implementation of alternate modes of dispensing but it is also important to quantify what they are risking or giving up. Therefore an indepth cost-benefit analysis on behalf of the LHDs and their private partners is needed.

3. Legal Issues

There are several legal issues, liability in particular, that may hinder the implementation of any mass prophylaxis plan, including traditional PODs. Chester Lee Smith, from the Georgia Division of Public Health hosted several meetings with BENS members and their legal representatives between October 2003 to January 2007. During these meetings it emerged that the liability issue was of great concern to all potential partners in the private sector (Smith, 2007). The BENS members at these meetings recommended a new legislation or changes in current legislation such as the state 'Good Samaritan' law that would protect them from legal liability and litigation occurring from incidental injuries but not from willful negligence (Smith, 2007). Since most partners in almost all alternate modes of dispensing that have been identified and tested in this paper are a part of the private sector, it is crucial to lay the liability issue to rest through further research before progress can be made.

H. CONCLUSION

The anthrax attacks in the United States have shown that civilian population is vulnerable to terrorist attacks involving bacterial pathogens (Lee, 2007). The concept of using PODs to dispense prophylaxis available through the SNS will clearly be unable to prophylax entire populations in 48 hour due to resource restrictions. Alternate modes of prophylaxis are therefore required to reduce the pressure on and fill the gaps left unfilled by our current approach.

Based on extensive review of literature review ten alternate modes of dispensing that are considered best practices were identified. Qualitative analysis cannot directly assess the efficiency of these alternate modes of dispensing. This is because each alternate mode of dispensing has certain strong attributes that make it highly efficient and certain weak attributes that make it less desirable. Developing and testing each alternate mode of dispensing for efficiency in any jurisdiction can be time consuming and burdensome especially when LHDs are understaffed to perform day to day activities (Santiago, 2006). The first step would therefore be to create a tool to analyze their efficiency in terms of select attributes.

MAVF is an approach that supports disparate attribute decision-making by taking into account the trade-offs a decision maker is willing to make between attributes (Belton, 2002). The process reveals and documents decision makers' preferences and easily determines their points of disagreements; at the same time it can perform marginal and sensitivity analysis rapidly under a variety of scenarios. The first step for MAVF is to create an objective hierarchy of attributes. Since most alternate modes of dispensing fall into one of two categories: modes that dispense to the general public and modes that dispense to a specific subset of the general population it was necessary to create two models in order to maintain attribute independence. In Model A, speed is an important attribute but this was replaced in Model B by the number of people that can be reached (since the mode would have a finite cap). Percent staff reduction (with two sub attributes 'Clinical' and 'Non-Clinical') and security (with two sub attributes 'Site' and 'Transportation') were attributes that were common in both models. All three criteria influence the final decision as to which alternate mode of dispensing is most viable. For

example, an alternate dispensing option may be very efficient in terms of its speed but may have very high security demands, making that option less desirable than another with a lower speed but also lower security requirements.

These models were applied to LAC to test which alternate mode of dispensing would have the best overall efficiency as compared to other options. Therefore each alternate mode of dispensing was defined in significant detail as to how it would look like in LAC. The data for each alternate mode of dispensing are collected through careful review of journal articles, attendance at exercises as evaluators, after-action reports and information available online. These quantified values were standardized using individual value function so that all measurements were defined between 0 and 1 with common unit values, thus making attributes cross comparable. The upper and lower bounds of performance were set at points where a performance above or below provided no added benefit to overall efficiency. Relative Importance or the weights for each attribute were set by a committee comprised of experts from Public Health, Emergency Medical Services (EMS), Law Enforcement and Fire Departments. The information was entered into an Excel spreadsheet along with assessed weights to calculate overall effectiveness.

According to our baseline analysis the door to door dispensing option followed closely by the pharmacy option were the two best options for mass prophylaxis to the general population. Both options provided 100% reduction in staffing and a speed of dispensing that was much higher than that of a POD. The drive-thru dispensing option, which seemed to be the most popular option according to our literature review, was the worst option by far failing to perform well on any attribute. The Pharmacy Option was the only option that provided any added benefit in terms of security. The model was rerun using security and weight input of law enforcement officials only. According to the law enforcement input the top two options in Model A were left unchanged, however the overall efficiency of the pharmacy option was lower as it no longer provided added benefit in terms of security. According to the one way sensitivity analysis in terms of security weights it is hard to justify the number one option when security weight was low to medium, however when security weight was significantly high the pharmacy option was clearly the better option. This trend was reversed for the weights of speed of

dispensing. The changes in weights of percent staff reduction did not affect the output. These results were confirmed by a two way sensitivity analysis. The drive thru option under no circumstance was an efficient option. Assumptions made in Model A, such as the number of pharmacies dispensing prophylaxis in the pharmacy option, the number of postal carriers available in the postal option and changes in POD baseline were also tested and had no impact on the outcome. This showed that the results obtained from Model A were robust and applicable.

Similarly, Model B was tested at baseline and based on security weights. The Civil Service Option and the Kaiser Permanente Option were the two best options in both circumstances. According to the one way sensitivity analysis, Kaiser Permanente Option was replaced by the Hospital POD option when security weights were extremely high and was replaced by the Business POD option when the weights on maximum numbers reached was extremely high. Nevertheless, according to the two way sensitivity analysis, the Civil Service Option and the Kaiser Permanente Option were the most efficient options according to all possible combinations of attributes. The outputs were not affected by any assumptions. This showed that the results obtained from Model B were robust and applicable.

The analysis and results provided in this paper represent the public health point of view. It is highly recommended that LHDs involve all stakeholders as they are developing their objective hierarchies in order to obtain buy in from all partners. Doing so will make the results acceptable to all and make implementation of the findings much easier. If LHDs choose to develop portfolios of alternate modes of dispensing they must take double counting of numbers into account in order to accurately estimate the number of people that can be reached using the portfolio. It is highly recommended that LHDs consider implementing a SIPs plan due to the uniqueness of the population served by this option. Finally, this paper does not take into account the costs of preplanning or implementation, it does conduct a cost-benefit analysis of alternate modes of dispensing nor does it take into account legal issues that may hider the implementation of alternate modes of dispensing. These issues require further research before alternate modes of dispensing are implemented.

Nevertheless, based on the robustness of our results in this paper we can thus conclude that alternate modes of dispensing reduce the pressure on PODs in two ways. One, by reducing the number of people that go to PODs and two, by reducing the pressure on limited resources such as security and staffing. As seen in this paper, MAVF can provide decision makers with an important tool to compare disparate attributes. The process takes into account the relative importance of each attribute according to the decision maker and provides recommendations, quickly and efficiently, as to which alternate mode of dispensing would be most resourceful. This lets decision makers choose which alternatives to pursue first.

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APPENDIX

Appendix 1
Survey Part I – Determining Security Needs

Security Score: Based on a scale of 1-10, with 1 being the lowest and 10 being the highest, how would you rate the security requirements for the given alternate mode of dispensing, based on your professional experience, in terms of site security and transportation security? (Mark your ratings on each line, total 22 lines)

	DISPENSING OPTIONS	SECURITY FOR	SECURITY SCORE									
1	Traditional POD	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
2	Pre-positioning of Medications for Government Employees and their Families	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
3	Pre-positioning of Medications for Hospital Patients, Staff and Families of the Staff	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
4	Dispensing of Medications at Private Businesses	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
5	Dispensing of Medications to Sheltered in Populations	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
6	Dispensing of Medications to Students at Colleges and Universities	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
7	Dispensing of Medications to Hotel Chains for their Residents, Employees and Families of Employees	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
8	Dispensing of Medications to Members of Kaiser Permanente	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
9	Door to Door Dispensing	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
10	Drive Thru Dispensing	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10
11	Dispensing to the General Public Using Pharmacies	Site	1	2	3	4	5	6	7	8	9	10
		Transportation	1	2	3	4	5	6	7	8	9	10

Appendix 2
Survey Part II – Determining Relative Importance

A. How would you divide <u>20</u> poker chips among the three categories stated below (based on their relative importance according to your professional experience)? (Write or type in numbers, should add up to 20)

1. Speed of Delivery - _____ Chips
   (Speed – Defined as the number of people dispensed to per hour per site)

2. % Staff Reduction - _____ Chips
   (% Staff Reduction – Defined as staffing requirements lowered by what percent if the given alternate mode of dispensing is used)

3. Security Associated with the Option - _____ Chips
   (Security – Defined as the security rating for the alternate dispensing process)

B. How would you divide <u>20</u> poker chips among the three categories stated below (based on their relative importance according to your professional experience)? (Write or type in numbers, should add up to 20)

1. Maximum Number Reached - _____ Chips
   (Number of people reached – Defined as how many people can be reached using a given option)

2. % Staff Reduction - _____ Chips
   (% Staff Reduction – Defined as staffing requirements lowered by what percent if the given alternate mode of dispensing is used)

3. Security Associated with the Option - _____ Chips
   (Security – Defined as the security rating for the alternate dispensing process)

C. How would you divide <u>20</u> poker chips between the following two categories stated below (based on their relative importance according to your professional experience)? (Write or type in numbers, should add up to 20)

1. %Clinical Staff Reduction - _____ Chips
   (% Clinical Staff Reduction – Defined as clinical staffing requirements lowered by what percent if the given alternate mode of dispensing is used)

2. % Non - Clinical Staff Reduction - _____ Chips
   (% Non - Clinical Staff Reduction – Defined as non-clinical staffing requirements lowered by what percent if the given alternate mode of dispensing is used)

D. How would you divide <u>20</u> poker chips between the following two categories stated below (based on their relative importance according to your professional experience)? (Write or type in numbers, should add up to 20)

1. Transportation Security - _____ Chips
   (Transportation Security – Defined as the security rating for transportation as required by the alternate mode of dispensing)

2. Site Security - _____ Chips
   (Site Security – Defined as the security rating for the physical site as required by the alternate mode of dispensing)

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